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THE

MOON AND THE WEATHER.

THE PROBABILITY OF LUNAR INFLUENCE RECONSIDERED.

SECOND EDITION.

CONTAINING

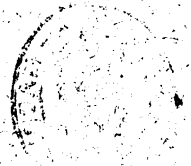
PREDICTIONS OF STORMS FROM DECEMBER, 1885, TO MAY, 1886, INCLUSIVE.

BY

WALTER L. BROWNE.

LONDON:
BAILLIÈRE, TINDALL, AND COX,
20, KING WILLIAM STREET, STRAND.

1884. 2.



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PREFACE.

In the following pages the lunar theory is often spoken of, but no attempt is made to demonstrate that theory; not because such demonstration is impossible, for it can be demonstrated, and its truth decided in the most positive manner. Considering the long and difficult chain of causes and effects, any demonstration in these pages would be impossible from the complex nature of the subject, and would require numerous figures and diagrams illustrative of principles employed in it, and also synoptic maps for many weeks, or months, in succession. Many assertions are here made, every one of which, however, has been fully corroborated by the facts shown by observation. More than twenty-five years of observation and daily practical work, undertaken with the special intention of investigating the popular belief in the moon's influence, has resulted in putting this long undecided question beyond doubt. 'Prevision is the test of true theory,' and the reader will find, at the end of this work, the prediction of areas of depression for the British Isles and other places for several consecutive months, with the dates of their occurrence and places where they will strike our coasts; and, by comparing them with the weather map in the *Times*, it will be found, with perhaps a few exceptions, that these areas of depression, as in-

dicated by the isobars, will arrive on or between the dates, and over or near, to within about 5°, the places mentioned.

Astronomy is a science whose laws are expressed in the periodical recurrence of certain phenomena in time and place: and, without the intervention of a miracle, these phenomena must take place. Storms and weather generally have been supposed by some writers to be capable of scientific prediction, although nothing of the sort has ever been attempted, and we are far from claiming for our predictions anything approaching to the accuracy of eclipses or other astronomical phenomena. We hope to show that storms, or gyratory motions of the air, do obey certain laws, which are sufficient for their prediction roughly; and these laws are a deduction from the theory of the effects produced by the attraction of the moon on the earth's atmosphere. Storms and meteorological phenomena have shown no such periodicity of sufficiently decided a character to afford a basis upon which to construct any theory of recurring periods that can serve as a precedent for prediction. The forecasts of the late Admiral Fitzroy were an acknowledged failure, and those of his successor do not seem to have attained a much greater degree of accuracy. All we know is confined to proximate causes and effects, and some larger natural laws, which do not in the least account for the actual conditions upon which the effects depend. The weather, in its larger and minute variations, must be governed by law, or there can be no such thing as a science; and it may be a law whose very purpose is to prevent such absolute periodical recurrence. And this is, in fact, what is the case: the law is periodical and recurring; but from the action of certain causes the periodicity is

translated to other areas of the earth's surface every two weeks; thus, for a given place, there is, in the course of any period of time, practically no absolute periodicity or recurrence of precisely similar conditions. The laws are such that a periodicity of weather is prevented.

The effect of the moon's attraction in producing the tides of the ocean has been known since the time of Newton, although it is a subject yet imperfectly understood. Most people have thought that the atmosphere must also have its tides, and La Place, in his 'Celestial Mechanics,' applied the theory to these aërial tides; but theory, even in his hands, could not overcome the exceedingly complicated mechanical difficulties of the atmospheric movements. The theoretical conclusions of La Place have been corroborated by barometrical and anemometrical observations since his time, as one sees in the works of M. Bouvard, Lubbock, Howard, Sabine, Elliot, Bergsma, Rykatchew, and others; but this influence has been considered too feeble in its effects to have any determined influence in producing weather changes, and therefore has been put aside as a true cause. It is true, then, beyond doubt, that some influence is attributed to the moon, and that it is faintly shown by instruments; but the effects can scarcely be called 'tides,' in the general meaning of the word. Storms, tempests, cyclones, are the results of the moon's action, and these are the most remarkable phenomena that first present themselves to us, and they are distinctly traceable to her influence, and all conditions of weather depend on them.

The fact of some influence being shown depending on the moon, and also the very apparent irregular recurring periods of barometer and thermometer

about which Webster has written in his very interesting 'Recurring Periods,' seemed to demand some further inquiry, and led the writer to form some conception as to the general law of such periods, and to deduce the necessary consequences from it. The facts observed do agree perfectly with the theory developed, and storms have been predicted for two years past as to their time and place. The lunar theory explains all those conflicting anomalies of atmospheric motions which have up to the present received only a very imperfect explanation. It unites facts and reasoning in the most harmonious manner, and agrees with all of them. If the predictions are correct, there can be no possible doubt as to the truth of the theory here advocated; for they are the interpretation of that theory. All physical science reposes on a belief in really existing material bodies with certain powers or forces; and, that they have these powers is supported and verified by prediction of the phenomena they cause. It explains how the phenomena are caused, and it is in this conception of the inter-relation of bodies, and the action of their respective forces, that the basis of science lies. This is the first time that the theory of the moon's attraction has been brought forward to account for storms and weather changes; for up to the present the construction of any theory having this force for its primary cause has not even been thought of, or at least deemed possible. Yet such a theory is possible, and, as stated, clearly demonstrable from already existing principles, laws and forces, and, that from the simple fact of the sun and moon's attraction, which has a real, an acting, and effective force on the atmosphere.

The truth of science is in the truth of ideal construction; its abstractions are formed out of sensible

concretes; its truths are applicable to reality in the precise shape in which the ideal constructions express the real facts. The lunar theory expresses the facts, and it is the moon's influence which causes storms, directs and guides them, along with the atmospheric currents of which they are composed.

All works on meteorology show the absence of any knowledge of what that force is which is the 'primum mobili' of the winds: some frankly state this; others only indirectly admit it. In vain the phenomena is sought to be explained by the action of heat, moisture, electricity, rotation of earth, and centripetal and centrifugal forces alone:—all these give but an imperfect explanation, which leave us just as far off as ever from the final result, which is prediction. When all explanation is exhausted, the most superficial reader can see that the key to the whole is wanting, and consequently the explanation is imperfect, and in some degree impossible; these considerations led the writer to fall back upon what seemed the most probable cause—the moon's attraction.

Fresnel remarks:*

'There are certain laws so complicated and so singular, that observation alone, aided by analogy, could never lead to their discovery. To divine these enigmas we must be guided by theoretical ideas founded on a true hypothesis.'

This remark is strikingly applicable to this subject: observation alone would never have led to any conclusive proof. Analogy has led us to think that there must be atmospheric tides; and the moon, it cannot be doubted, does produce tides, but does not produce them so as to cause them to correspond to the analogy. The case requires the application

* Quotation from 'The Principles of Science': Jevons.

of some reasonable hypothesis first, to see if it will account for the facts shown by actual daily observation, and these are rendered comprehensible by the theory, and their prediction rendered certain. The central area of depression cannot pass anywhere over the earth's surface without its passage being traced, and its advent known, days, weeks, or even months beforehand. The satellite depressions appear to be governed by a subordinate law, and depend on the larger and primary areas. Now, satellite depressions are often deep, sudden, and violent, and their prediction is perhaps of more consequence than the larger ones; but it is hoped the difficulties they present will be overcome.

As stated, no attempt can be made in this little work to explain the moon's action. A large volume might be written on details alone, and on the consequences this theory gives rise to; the results have been so unexpected, manifold, and curious, that further examination and study is necessary before attempting to assert anything positive as yet. In order that our readers may not be in the dark as to what is meant by the lunar theory, we will briefly state it in the following terms:

All changes in the force and direction of atmospheric currents, and with them storms, are caused by the attraction of sun and moon on the atmosphere. The passage of the moon from equator to equator determines the length of a cycle; and during this period of about thirteen to fourteen days, the moon causes a change in the direction of atmospheric currents in opposition to a force which resists that change, which force is produced by the rotation of the earth on its axis. The complication of phenomena observed is primarily the result of two forces.

There can be no recurrence of absolutely similar conditions to the same place ; for the initial starting point of moon on the equator is constantly changing, and also the path of her motion in declination, as it would appear if traced over the earth's surface.

As the moon passes from equator to equator again, she causes the meteorological pole to recede from the terrestrial pole, in an opposite direction, by a number of degrees equal to her declination ; *and it is round this pole that the primary areas of depression circulate ;* and the secondary depressions *appear* to circulate round and into the first; thus, storms would revolve in circular orbits, were it not that such motion is destroyed by the earth's rotation and other causes, and, according to the law of the composition of forces, forms a parabola.

New and full moon in apogee or perigee, and in or near equator, are periods of greater atmospheric disturbance to those portions of the earth over which they occur. These areas of disturbance obey a certain and invariable law with regard to their place, depending on the declination of the sun and moon at these times.

The attraction of sun and moon only accounts for the observed phenomena up to a certain point; other causes are called into operation, which appear to be due to magnetism.

In the north temperate zone there are two large separate systems of circulation. Lunar attraction explains the first of these, but not the second. Each of these systems contains from eight to nine revolving storms, which circulate round it, and have a progressive motion eastward in a direction situated between the terrestrial and meteorological poles.

Theoretically, precisely similar effects ought to be

shown in the southern hemisphere, corresponding to those in the northern, but considerably modified by the different configuration of land and water.

Observations were begun with the intention of establishing some functional relation between the moon on one side and the grouping of the anticyclonic pressures on the other. Why do they group themselves as they do? Are the anticyclonic pressures dependent on the cyclonic depressions or the reverse? Are not both different aspects of the same cause? These were the principal questions requiring solution, and which have been solved, first theoretically and afterwards by prediction; and, although it is impossible to trace each particular depression to its primary cause, yet the larger ones obey the law, and are distinctly traceable; and this is what we expect the predictions will prove. If we have succeeded in deducing the faintest form of order in the vast and complex domain of the science of meteorology, the success will indeed be great, even if we only point out the direction in which we must look for the 'missing link' in this our science.

There are many faults and shortcomings in this little work: it has been written in the middle of exacting and pressing daily duties; and, owing to the author living abroad, unexpected difficulties presented themselves.

W. L. BROWNE.

35, Grande Morskaya,
St. Petersburg, Russia, 1884.

PREFACE TO THE SECOND SERIES.

In publishing a second series of 'forecasts' of storm depressions for the British Isles, I am encouraged by the large percentage of correct predictions for the months of April, May, and June, 1885. Speaking of those for the British Isles only, the result of an analysis gives between 70 and 75 per cent. of fulfilled predictions, if I take those which occurred the day before or the day after the date stated, and which may, I think, be reasonably claimed. Most of these storm-predictions occurred at the time and place indicated, a few arrived either the day before or after, and five or six depressions arrived that were not predicted at all.

Thus, for the month of April, the following depressions may be said to have been successfully predicted in my first edition: Those of the 4th, 5th, 6th and 7th, 9th and 11th, 20th, 21st, 22nd, 24th and 25th; that indicated for the 3rd arrived on the 4th.

May 4th, 4th or 5th, 6th and 8th, 7th and 9th (two depressions actually passed between the 6th and the 9th), Anticyclonic Period 10th to 14th; 16th, 17th or 18th to North Sea, 19th, 21st to 23rd, 23rd to 24th, 27th or 28th. The depression of the 19th arrived over N.W. coasts instead of S.W. The depression indicated for the 21st to 23rd remained almost stationary from 20th to 21st. That indicated for the 30th arrived on the 29th. The depression indicated for the 13th passed over France beyond 5° of the place mentioned, though it was the depression expected about that date.

June:—The depressions of the 4th or 5th, 10th or

11th (this was violent over Denmark); 11th or 12th, 24th, 25th, 14th, 16th, 28th or 29th, 30th. The depression of the 11th or 12th passed the centre of Scandinavia instead of the south. That indicated for the 16th arrived on the 17th. That of the 30th approached N.W. coasts, not Irish. If I take the month of April for analysis, I find that out of ten depressions not marked 'uncertain,' seven were correctly predicted; out of five 'uncertain,' two or three were correct. If we look at the chart of the principal depressions for April, it will be seen that, of the four principal depressions there given, three of my predicted ones were absolutely correct in time and place. To these I can add a fifth. A depression did really pass Stornoway on the 21st, and it was clearly shown by the German weather reports; but the English ones stated it to be an 'indefinite' one. It was not, however, deep, as I expected it would be, probably not more than two-tenths; so in respect of depth I was not correct.

The periods may be said to have shown but a vague correspondence. From the 4th to the 7th was indicated as a stormy period; and with the unsettled period that followed it to the 12th, the barometer remained low with a cyclonic movement of the air. From the 16th to the 19th, though not very decidedly anticyclonic, except for a short time, was a period of relatively higher barometer. This higher pressure gave way owing to the advance of the depression of the 20th, which was indicated by me, and was further decreased by the depression of the 24th off W. coasts, also indicated as probable. From the 20th to the 23rd, including the unsettled period to the 25th, 26th, was a stormy and unsettled period. From the 26th to the 3rd of May was a period of relatively higher barometer, though not anticyclonic.

Out of ten depressions for May not marked uncertain,

seven or eight were correct. One indicated from the 21st to 22nd arrived on the 20th. Two occurred that were not predicted. That predicted for the 23rd or 24th over the south of England or north of France arrived over the North Sea on the 23rd. From the 8th to the 16th, though not decidedly anticyclonic for the whole period, was highest in England from the 10th to 13th, and was a period of relatively higher barometer. From the 18th to the 24th was unsettled for all British Isles, and the weather corresponded to the character I gave it.

Out of nine depressions for June not marked uncertain, seven were correct, though June shows less accuracy than the other months. The depression of the 2nd or 3rd arrived over W. coasts instead of S. That indicated for the 4th or 5th came on the 3rd; that for the 10th or 11th came on the 9th or 10th; that for the 23rd came on the 22nd. The periods this month showed no correspondence.

Now out of twenty-nine depressions not marked uncertain, twenty-two have been predicted, some were absolutely correct, and all arrived with an approximate exactitude in time and place. Out of eighteen marked 'uncertain,' ten only were correctly predicted. Out of forty-seven depressions for the three months, thirty-two may be said to have arrived, and were approximately correct with regard to time and place; but, if we admit that those depressions which arrived on the stated day within the British area, and beyond the limit of 5° and within the limit of 10°, were correctly predicted, then we have a much larger percentage of correct predictions. I think that I have shown that a majority have arrived with great accuracy. It is true that many of them were of little importance, yet they were there, and I begged that all depressions, if indicated by the isobars, whether subsidiary or otherwise, might be counted as

depressions. The American storms coincided exactly with the days mentioned for their expected arrival over the British area or otherwise; for the latitude claimed by these American storms is certainly great—from France to Norway.

In the face of this evidence, which all having the necessary knowledge can examine for themselves, it is impossible to assert that an approximation has not been shown in the prediction of storm depressions; and it is evident that the majority can be predicted for the British Isles, very few exceeding 10° of the places mentioned. This cannot be the result of chance, especially as we see the approximation holds good for three months in succession. Now I must state that the spring and summer months show the lunar influence more faintly than the winter ones. The period from November to February is the best for testing this theory, and I have often —under favourable circumstances—obtained for these months 80 per cent. of fulfilled predictions, especially those storms which traverse north-temperate zones, while the summer months give an average of about 60, or 65 per cent. I believe the following months will show an average of about 70 per cent. of fulfilled storm depressions. In publishing these forecasts, I am only actuated by the desire to prove what I asserted in my book, 'The Moon and the Weather,' and to draw attention to a theory which I hold, and have been the first to propound, with regard to storms and weather changes. I have no ambition to become a weather prophet, and I distinctly disavow any prediction of the weather in its popular sense. The most I attempt, in this respect, is to state in general terms that a certain period will be stormy or unsettled, or probably anticyclonic. I am convinced that depressions can be predicted by my theory, and which I have stated in my work on pages 10, 44, and 110. It is useless to think of satisfying

captious critics, or those who desire absolute accuracy in an attempt of this sort, and other impossibilities. I affirm again what I stated at page 120 in 'The Moon and the Weather': 'The principle of law and order will be perceived by an approximate accuracy.'

With regard to the book itself, I certainly must plead guilty to the charges of vagueness which were brought against it in some quarters. In my endeavour to be comprehensive, and to avoid details and the discussion of uncertain laws, I have fallen into the error of being less explicit on some points than the subject required. But these defects can easily be corrected in any further edition. I had discovered too late that of the months there given, two were favourable for putting my theory to the test, and was thus consequently hurried in preparing the manuscript for the press, and that in the midst of very pressing duties which occupied nearly all my time.

I shall make a few remarks to those who choose to test the following months. If a depression arrives, either subsidiary or secondary, be its depth what it may, I beg it may be counted as a depression. I still limit myself to 5° for the arrival of a depression over any place where the place is indicated. Notice whether the prediction of American storms given by me coincides with that given in the telegram as the date of their arrival over or near the British area. With regard to these, they may or may not reach the British Isles, and very often arrive as filling up depressions. Depressions marked 'uncertain' are generally those which occur when the moon is over or near the equator, and when they do occur will, probably, be deeper and more dangerous than others. A greater accuracy will be shown for depressions north of 57° than those to the south. I have stated times and places when and where I expect the storm-track will pass, and over those places

the barometer will be relatively lower than the moon for the season. There appears to be more than one storm-track—one for north temperate zones and another for the south. Sometimes, as soon as the one in the north has passed off, the southern arrives, and in this case they frequently run one into the other. In the first case, under certain positions of new and full moon in longitude and declination, storms follow each other in the same track from five to eight days; in the second they may follow each other, though altered in direction, for from the 10th to 14th or 15th. My remarks with regard to the storm-track only refer to the northern one. It appears that with the present maximum declination of the moon 18°, and the longitude of the new and full moon in the following months, that the regions most affected by the *central* storm-tracks will be the north of Scotland and extreme south coasts. In three instances only does the central storm-track cross Scotland actually, but generally to the north of it. Nevertheless, if the calculations for the passage of the southern storm-track are correct, we may expect the deepest depressions again when the moon is over or near the equator, and theory indicates they frequently cross the southern part of the British area.

One thing is evident to the most superficial observer in this department of science, and that is, that meteorologists are still without the slightest clue to original acting causes of storms and weather changes: if these forecasts point out, even ever so faintly, the direction in which we must look for light on the subject, their object will have been gained.

W. L. BROWNE.

ST. PETERSBURG,
November, 1885.

PREDICTIONS.

DECEMBER, 1885.

DATE	
1	*Depression between 1st and 3rd; probably deep; uncertain over British area, probably N.W.
3	Depression S.W. coasts 3rd or 4th; probably shallow.
4	Depression N. Scotland 4th or 5th; probably deep. Depression Bodo 4th or 5th.
5	Depression N. Scotland 6th or 7th, with subsidiary depressions across centre of British Isles, from 6th to 8th; probably deep.
7	Depressions N. coasts 8th or 9th, between Scotland and Christiansund.
8	The 7th and 8th squally and unsettled in centre and N.
9	Depressions 9th or 10th S.W. or S. of British Isles; uncertain.
11	Depressions 11th or 12th across N.W. of British Isles; uncertain.
12	The 12th and 13th days of relatively higher barometer in N.
13	Depression 13th or 14th, British Isles; probably stationary from 13th to 15th over W. area; American storm.
16	Depression 16th or 17th, S. coasts; uncertain.
17	18th, 19th, and 20th, probably anticyclonic over England, Germany, and Austria.
18	Depression N. Scotch coasts 18th or 19th, or relatively lower.
19	Depression Christiansund or little to N., 19th. Depression England 19th; uncertain.
20	Depressions extreme S. coasts 20th to 22nd; uncertain.
21	Depression Christiansund 21st; probably deep. Depression between 21st and 23rd, British Isles.
23	Depression across N. Scotland 24th or 25th; probably deep.
25	Depression 25th or 26th, British Isles; uncertain; American storm.
26	Probably anticyclonic after the 26th to the 2nd of January.
29	Depression 29th or 30th, S. of British Isles; uncertain.
31	Probably anticyclonic over North Sea, S. Denmark, Germany, from 31st to 2nd.

* If this depression marked 'uncertain' does not arrive, anticylonic conditions will exist until the 5th.

DECEMBER.

Remarks.

Stormy and unsettled in N. of Scotland, and probably affecting British Isles, except extreme S., from 6th to 10th, and may last to 14th or 15th. The storm-track crosses the N. of Scotland between 6th and 8th, and is followed by another in the S. on the 10th and 11th or 12th; pressure may be relatively higher than on any other day in the period from 6th to 14th or 15th.

Depressions may probably exist off American coasts between the 6th and 8th, 12th and 13th, and 20th to 23rd.

A series of deep depressions will pass between N. coasts of Scotland and Iceland between the 20th and 23rd, and may affect N.W. area. Stormy in N. Atlantic 20th to 23rd. The periods in which there are shown to be no depressions, or where marked uncertain, will be anticyclonic, or periods of relatively higher barometer, if those depressions do not arrive.

JANUARY, 1886.

DATE	
1	Depression centre or N. Scandinavia, 1st.
2	Depression S. coasts, 2nd or 3rd; uncertain.
4	Depression Christiansund or little to N., 4th. Depression extreme S. coasts, 3rd or 4th; uncertain.
5	Depression N.W. or N. coasts, Stornoway, 5th; deep.
7	Relatively higher barometer from 6th to 9th, or perhaps from 3rd in S.
9	Depression British Isles, 9th or 10th; American storm.
14	Depression 14th or 15th, extreme S.W. coasts; uncertain.
15	Relatively lower N. Scotland, 15th to 19th; lowest 17th or 18th.
16	Probably anticyclonic over N.W. coasts, 14th; over England, 15th, 16th; France and Germany, 17th.
18	Depression Faroe Isles to Christiansund, 18th to 19th; deep. Depression 19th or 20th, Ireland or W. coasts.
20	*Depression extreme N.W. coasts, N. of Faroe, 20th, 21st; deep.
23	†Depression over British area, 23rd to 25th; uncertain.
28	Depression 28th or 29th, S. coasts; uncertain.
29	Depression Bodo, 29th.
30	Depression approaching N. Scotland, 29th or 30th.
31	Depression 31st, Orkney Isles; deep.

* This depression may pass between N. Scotland and Faroe on 22nd.

† If this depression does not arrive, probably anticylonic after 22nd to 29th.

JANUARY.

Remarks.

From the 30th of December to the 4th of January, relatively low pressure over Central Scandinavia to N. Russia.

From the 6th to 8th, probably, relatively higher barometer over British Isles, and from 14th to 16th over England.

From the 15th to 18th, relatively lower in N. Scotland.

Probably anticyclonic in N. 22nd to 29th.

Depressions may probably exist off American coasts on or between 4th and 7th, Nova Scotia. From the 15th to 16th, uncertain; 18th to 20th, 24th to 26th, 28th to 31st.

Stormy in Atlantic from 3rd to 5th, and 28th to 30th.

FEBRUARY, 1886.

DATE	
1	Depression Stornoway or Shetland 1st; deep, to Scandinavia and Finland.
3	Depression over British Isles, 3rd or 4th; probably S.
5	Depression N.W. coasts, 5th; uncertain.
7	Depression S. or S.W. coasts, 7th or 8th; probably deep.
10	Depression S. or W. coasts, 10th or 11th; uncertain.
11	Probably anticyclonic 11th, 12th, and 13th, S. England; Austria, 14th.
12	Depression Christiansund to Baltic, 12th or 13th.
14	Depression extreme S. coasts, 14th or 15th.
15	Depression Christiansund or extreme N. coasts, 15th. Depression 15th or 16th, Ireland or British Isles.
16	Depression between Iceland and Faroe Isles, 16th or 17th.
19	*Depression N. Scotland, 19th or 20th; uncertain; American storm.
24	Depression between Bodo and Christiansund to Baltic, 24th; uncertain. Depression 24th or 25th, British Isles.
26	Depression S. coasts, 26th or 27th; uncertain.
27	Depression extreme N. coasts, Christiansund, 27th or 28th.
28	Depression across Scotland, from W. coasts, to Orkney or Shetland, 28th, 1st; deep.

* This depression may arrive on the 21st; probably deep.

FEBRUARY.

REMARKS.

Probably anticyclonic from 4th to 11th or 12th.

Storm-track passes the N. of Scotland; Shetland or Christiansund between the 29th and February 3rd; probably followed by another in the south to 7th or 8th.

Barometer relatively lower in N. coasts, Shetland, Christiansund, 11th to 14th.

Probably high pressure over England 11th and 12th; France, Germany, and Belgium, 13th and 14th.

From the 27th to 3rd March, stormy and unsettled, particularly in N.

The storm-track passes N. and N.W. coasts 26th to 1st or 2nd of March.

Depressions off American coasts, 11th or 12th, between 14th and 17th.

*MARCH, 1886.

DATE	
4	Depression N. or N.W. coasts, 4th or 5th; uncertain.
6	Depression extreme S.W. coasts, 6th or 7th; uncertain.
9	Depression extreme S.W. coasts, 9th to 11th.
11	Probably relatively lower N. Scotland; Shetland, 11th to 14th.
13	Depression S. Scandinavia, 13th.
15	Depression Christiansund, 14th or 15th; extreme S. coasts, 14th, 15th, and deep.
16	Depression between Faroe and Iceland, 16th.

* Conditions appear too complicated during the latter part of March to admit of analysis.

Probably anticyclonic from 3rd to 11th.

Probably anticyclonic from 16th to 20th; highest, 17th, 18th.

Depressions of American coasts between 14th and 16th.

APRIL, 1886.

DATE	
4	Depression Christiansund or to N., 4th; uncertain.
5	Depressions S. coasts, 5th to 7th; uncertain.
7	Depressions N. coasts, Shetland, 7th or 8th; Christiansund, 8th.
10	Depression S. coasts, 10th to 12th.
11	Depression extreme N. coasts, Christiansund to Bodo, 10th to 12th.
12	Depression S. of Iceland, 12th or 13th.
14	High over British Isles, 12th, 13th, 14th; highest in N. and N.W., 12th.
15	Depression British area, 14th, 15th; American storm, uncertain.
18	Depression N. Scotland, 18th: uncertain.
21	*Depression between Shetland and Christiansund, 21st.
22	Depression, 21st or 22nd, N. Scotland, or over British Isles.
23	Depression, N. Scotland, Orkney, 22nd.
25	Depression S. of England, 25th, probably to North Sea.
26	Depression S. of British Isles, 26th or 27th.
30	Depression N.W. coasts, 30th.

* These three depressions may unite so as to form one, as shown by the isobars.

APRIL.

Remarks.

From the 7th to 10th, may be relatively lower in N. Scotland, Shetland, or Orkney.

From the 10th to 15th, probably anticyclonic or relatively higher barometer.

From 20th to 24th, relatively lower in Scotland.

From 20th to 24th, squally and unsettled from centre of British Isles to W. Storm-track passes N. Scotland.

From 26th to 29th or 30th, anticyclonic in relatively higher barometer.

Depressions off American coasts between 10th and 13th; 24th to 26th.

MAY, 1886.

DATE	
1	Depression N. Scotland, 1st to 3rd, stationary over British area*
4	Depression S. England, 4th or 5th; uncertain.
6	Depression centre or N. of Scandinavia, 6th.
7	Depression Orkney, 6th or 7th; probably deep. Depression centre of British Isles, 7th or 8th.
8	Depression Stornoway, 8th or 9th; probably 8th to Denmark or S. Norway.
10	Depressions 10th to 11th, S. coasts of England.
12	Depression 12th, S.W. Ireland, uncertain; probably nearly stationary, from 12th to 14th; deep.
15	Probably anticyclonic or relatively higher barometer from 15th to 18th. Depression 17th or 18th, N. or N.W. coasts.
18	Depression Bodo, 18th, 19th.
19	*Depression Stornoway, 19th.
20	Depression England, 20th.
21	Depression N. Scotland, 21st.
23	Depressions between 22nd and 24th, S.W. coasts.
26	Depression 26th to 28th, N. or N.W. coasts.
27	Probably anticyclonic to 31st.
31	Depression W. coast; uncertain.

* These three depressions may unite so as to show one by the isobars.

MAY.

Remarks.

From the 6th to 13th or 14th, stormy and unsettled.

From the 19th to 22nd, stormy and unsettled in Scotland, and probably also in S.

The storm-track passes N. Scotland between the 5th and 10th, and 18th and 23rd; squally and unsettled periods, probably, for all British Isles, particularly 7th and 8th, 20th and 21st.

Probably high pressure over Germany and Belgium 10th and 11th; 12th, S. Denmark to Baltic Provinces.

Depressions off American coasts 3rd, 10th to 13th, 20th to 22nd.

THE MOON AND THE WEATHER.

General remarks on the state of Meteorology.—The popular belief.—Absence of any truly scientific system of storm prevision.

It has been asserted over and over again by most scientific men of the present day that the moon has no influence on the weather. Innumerable articles and papers have been written to disabuse the public mind of such a fallacy. Every now and then the subject is brought before the public in some journal or periodical devoted to science or literature. It is to be doubted if those who write such articles have ever undertaken to examine the subject they write about so dogmatically. The general tone of their remarks is much as follows:—The progress of true science and extensive observation in a right direction has put this belief on one side as an exploded superstition, a dream and dotage of the past, only fit to be classed with witchcraft and Middle-Age superstitions. The moon does not affect the weather; exact and impartial registers give no countenance to this supposition; it is an 'enduring fallacy' for which there is no foundation in fact. It has been frequently and fully proved that our satellite has no influence on the winds and rains. Physical science has made great progress in recent times, and Meteorological Departments have been established for a great number of years, and, if this influence had existed, it would have been discovered and demonstrated before now. And thus, if anybody has the temerity to assert that he believes with the people that weather changes are caused by the action of the

moon, he is pretty sure to be put down by the scientific meteorologists who have fathomed the depths of their science, and who have not yet been able to discover any such influence. It may be as well to recollect that scientific meteorologists, notwithstanding all their stations, self-registering barometers, mountain observatories, are not yet able to predict the weather nor yet even storms: the weather enigma is yet an unsolved problem.

The only influence attributed to the moon is that of clearing the sky of clouds when full, and even this has lately been denied—thus, the *rôle* of the moon, our satellite, is reduced to zero in this department of nature. In nearly all manuals and works we find her influence ignored, and all the old observations of past generations brought forward to prove it is purely imaginary and does not exist, except, perhaps, in such a vague and undetermined manner that nothing can be made of it. As to the moon herself, she is simply a worn-out satellite, covered with extinct volcanoes; an interesting object for the telescope, whose past history puzzles the genius of astronomers and philosophers. It is true she produces the tides, illuminates one half of the earth at once with her borrowed light, so calm, so fair and soft, but without the power to call forth and nourish life. These two functions stated, no other is attributed to her. She is exceedingly beautiful to gaze on as she sails a Queen through the blue heavens, and has furnished themes for poets and her light to lovers from the dawn of creation. The humble and uneducated affirm she plays a great part in nature: she rules and controls the weather as well as the waves, and, in their opinion, no Salic law excludes her from reigning supreme. The educated and the scientific affirm she does not. In the opinion of the former, the moon raises the waters; therefore she raises the air, which is lighter. The latter maintain that her influence is a scientific heresy.

Now this popular belief in her influence is no proof of its truth, any more than the universal belief in witches during the Middle Ages is a proof of the truth of witchcraft. Nevertheless, at the end of the nineteenth century we seem returning to several of the old beliefs and superstitions; only there is this difference: they are coming back clad in the garb of science. There are many worthy people fond believers in spiritual manifestations and the occult influence of one mind over another. We have our thought-readers, also a revival of beliefs in ghosts and apparitions; but clever people try to give these things a scientific explanation. Nowadays we are nothing if not scientific, and the succession of one discovery after another almost takes away our breath. It is open to doubt whether this haste is good for science, and ordinary minds cannot sift the wheat from the chaff; there is scarcely time to do it. However, even if the moon's influence be a superstition or a fallacy, then let it stand its chance with other revived superstitions and fallacies, and let it be examined in the light of modern science. There may turn out to have been some foundation for the popular belief in the old-world ideas, distorted and exaggerated, perhaps, but nevertheless having, in actual fact, some basis of truth.

The conquests of the human mind in the realms of nature have produced in our generation so much that is marvellous, that consequently an intellectual activity reigns never before witnessed in any age of the past. There seems to be a rising and fermenting of ideas and principles, together with a combining in new forms with new evolutions. New questions have arisen, and new theories must be developed; while the old ones must be re-examined and tested in the brighter light of modern times. Truths lying latent have to be brought out, and principles must find a newer and more general application. New doubts have suggested themselves, and

no thinking person can help partaking in the ferment around him. We are bound in this age to think and to go forward, or sink and be lost. Science has laid open to us undreamt-of forces and unexpected mysteries. On many subjects we find ourselves on new and difficult ground, where the battle must be fought and retreat not dreamt of until mysteries are cleared up. Science is a Divine trust,* 'and man is fulfilling his great mission in the world by using his intellect and his reason to discover those laws. It is a dedication of his powers to the highest purpose for which they were bestowed upon him.'

Monsieur Faye, not many years ago, wrote an essay to disprove the popular opinion. This essay is discussed at length by Mons. Henri de Parville in his 'Causeries Scientifique,' vol. xix., for 1879, to which work we refer our readers for his opinion of it; we cannot enter into a discussion of it here. We believe the last utterances on the subject in England were by Mr. Scott at the Health Exhibition, in a paper on the 'Equinoctial Gales—do they occur in the British Isles'? Mr. Scott is reported to have said:

'Most scientific meteorologists are disposed to give up, almost in despair, the idea of eradicating from the popular mind the belief in the influence of the moon on the weather.'

This is indeed true. This belief will not be eradicated. In spite of all that has been said to prove the contrary, the popular belief remains unshaken amongst the masses, and it returns ever and anon to disturb our scientific progress and the spirits of modern meteorologists. The masses, who cherish it, care little about science or philosophical writings, and works written to disprove it never reach them; while the moon is continually before their eyes, and the weather changes, affecting them in a greater or less degree, and they have inherited this belief from their forefathers. It is not astonishing that the

* We believe these words were spoken by the late Prince Consort.

efforts of science have failed to crush it; for there is an utter absence of true philosophical investigation and observation evident in nearly all works which have treated of it. Those who have really investigated the subject, and they are very few indeed, have, but with rare exceptions, never done so with that strict attention the question deserves. Others, and they are in the majority, have been much too absolute and dogmatic in their assertions that the moon has no influence, and have generally been too occupied in proving the beauty of their own theories to spare time for the investigation of a theory requiring an immense amount of time and labour, and also considerable practical astronomical knowledge, which few possess. There are modern theories, such as that of solar spots and their influence, and others, which require a good deal of bolstering up to make them acceptable, but which have not also any appreciable connection with the weather; for they are totally beyond any philosophical demonstration whatever; while, if we suppose that the attraction of the moon has an influence, there is, at once, a basis for further examination according to known laws; and that it is this force, the writer is able to demonstrate and prove.

It is difficult to believe that the popular notions on this subject are altogether without foundation. Lunar influence has its believers amongst all nations and tribes, and especially among those who are the best observers, and who are more concerned than any others in the weather and its effects. The Cossacks, Tartars, Fins, Tcherkess, Kirghes and Siberians are all firm believers in the moon's influence. The sailor, shepherd and farmer, of our country, and those of all Europe and America; the wild tribes of Asia and the New World, appeal to the moon as the controller of the winds and storms, of fair weather and of foul; and, indeed, as far as predictions or forecasts are concerned, they will tell you what

weather to expect with greater accuracy than the scientific meteorologist, with all his expensive instruments and finely strung calculations. Indications afforded by the physical appearances of sky and cloud are worth more to them for predicting the weather than instrumental indications. The sailor, shepherd, and peasant of the steppe, without any knowledge of philosophy or science, can tell you from his own resources, which are only those afforded by nature, the coming weather with great precision and exactitude, and generally scorn any artificial means; which, indeed, not being accustomed to, might only lead him astray.

This universal belief is not a little curious, and is as old as the creation. In the very first chapter of Genesis we read: 'Let there be lights in the firmament of heaven to divide the day from the night; and let them be for signs, and for seasons, and for days and for years.' Two thousand years before Christ, Aratus wrote of the moon's influence on the weather. Pliny, Virgil, and other ancient authors have also given their testimony in her favour. Hippocrates, in his treatise on 'Atmospheres, Waters, and Places,' and Aristotle, in his 'Meteorologics,' were the first who collected observations, and thus founded the first elements of observational meteorology. And no wonder this science should have been one of the very first to attract the attention of mankind! The spectacle of the various conditions of the sky; the beautiful celestial scenery presented by the clouds, with all the hues and tinges of colour that play on their frosted edges; the halo and the rainbow; the storm and tempest, have in them much that is marvellous and that chains the attention. Dull indeed that nature must be which fails to be captivated by the beauties presented to his gaze in this department of nature, and that is not overawed by her, occasionally, terrible manifestations.

We are led to maintain the reality of the moon's

influence from an exhaustive and complete examination conducted in every possible way during a period of twenty-five years, and the conclusion is, that the *rôle* of the moon has been greatly mistaken. The search has nearly always been for tides, and nothing of the sort is shown by observation; it is not by means of tides she affects the atmosphere; and, moreover, although the inter-tropical zone is the region, it would seem, that ought to be influenced most by her, it is in temperate zones her action is chiefly felt, and the result of her action no way resembles that of the tides. It would, indeed, be not a little curious if, after all, the public is right and the astronomers wrong; this would be an instance of the weak confounding the wise; and, if the theory dear to the public can be supported by the evidence of prediction—and this is the test to which we shall put the theory—it will be a curious instance of the triumph of popular opinion, one as old as the world and shared by all.

Meteorologists disagree amongst themselves, and the laws that are really stable and well-established with regard to the circulation of the air are very few in number. After having read and examined attentively most of the popular works on meteorology, it is impossible to resist the conclusion that meteorologists are like men fighting in the dark, or like an army without a general or commander. The key to the whole system is wanting. The great law which governs atmospheric circulation is unknown, and we get bewildered in the confusion of details, which, on account of the absence of some general comprehensive law governing the whole, receive only a partial explanation, and round which argument and controversy continually revolve. The laws, so called, may be reduced to one, that known as Buys Ballot's: 'It is a fact above all doubt that the wind that comes is nearly at right-angles to the lines between

the places of highest and lowest barometer readings. The wind has the place of lowest barometer at its left hand, and is stronger in proportion as the difference of barometer-readings is greater,' and this law was framed to apply to those rotatory areas of depression which travel across temperate zones, as well as cyclones, and experience proves it correct. It is, nevertheless, a law in a wider sense, and applicable to the general mean system of atmospheric circulation in the north and south temperate zones. We next have 'gradients,' which are obtained by the arithmetic division of the distance between the two places of highest and lowest pressure in nautical miles, by the difference of pressure observed simultaneously, stated in inches of the mercurial column. The wind has greatest force where the isobars crowd together, and, generally, the force of the wind, at any place, is proportioned to the difference of the barometric pressures between which it is, for the time, situated. The force of the wind, however, is not regulated solely by the gradients; and, it has yet to be determined what the other agencies are which affect it. Excess of pressure over a given area may be regarded as a statical force; and the velocity of the wind that blows from it, to the area of low pressure, according to Buys Ballot's law, bears some relation to this statical force; thus, the value of the gradient expresses the force of impulsion; and it has been shown that gradients of 1 in. of mercury to 170 miles have produced great disturbances over our islands. This law is applicable only when the storm is well within the area of observation, and must always remain very imperfect until the primary acting force is known, and also the amount of that force together with its geographical place on the earth's surface. This law is practically applicable only in an approximate manner, and in no way touches the question of weather prevision, except also in a very restricted manner. These are laws, it is true, but

laws on which no meteorologist, be he ever so scientific, dare venture to predict the course a revolving depression will take within the next six hours. We are absolutely in the dark with regard not only to the origin of storms, but also of that law which regulates their onward progress; and until this law, whatever it may be, is known, weather prevision will remain impossible. Works on the subject multiply details and facts without end, many of which the laws are uncertain. The generalization and great principles, by which means the facts can alone be understood, are totally wanting, and, consequently, the facts, however interesting, are of little use. The theory of Hadley is an important generalization, but it is extremely doubtful whether it is supported by the facts. Ferrel remarks, page 9:

'Accordingly we see that although Hadley's theory furnishes an explanation of the trade-winds, yet it does not account for many other remarkable phenomena in the motions of the atmosphere, but even requires motions to satisfy it entirely at variance with them. According to this theory there should be a current on the surface of the earth, from the pole to the equator, in a kind of loxodromic spiral, and a similar counter-current in the upper regions from the equator towards the poles. The barometer, also, should stand highest at the poles, where the air is coldest and most dense, and gradually fall as it is brought nearer the equator. But both of these, as we have shown, are contrary to observation. The position, also, of the exterior limits of the trade winds near the parallels of 28°, the flowing of the atmosphere in the upper regions from both sides towards these parallels, and a low barometer near the polar circles, cannot be explained by this theory, and have not been satisfactorily explained by meteorologists.'

Thus we see Hadley's theory explains the trades, and that is all, and the idea of the atmosphere flowing from equator to poles and the reverse, as usually represented, is an assumption, and nothing more. The form, also, of the circulation of air round and into the centre of depressions is far from being established with certainty, and there are movements of storms which have never received any explanation whatever. Storms sometimes back suddenly to the west and north-west;* they sometimes unite

* June 25th to 27th, 1883.

with other depressions, and take quite a different route to that on which they had originally started; but these anomalies are inexplicable up to the present on any theory whatever.

We have all sorts of theories—sun-spot theories; theories of cycles, of recurring periods; magnetic and electrical theories; influence of planets; but perhaps the greatest delusion of all is the first of these. There have been Meteorological Departments for at least the last thirty years, yet no progress is made in weather prevision. A violent storm may come down on our coasts any day or night without any warning being given whatever. This is, in one sense, a gain to the public, for it shows the complete absence of a knowledge of the first principles by which the science must be governed, and leads to the conclusion that meteorology as a science does not exist. Nature is subjective to the faculty of thought. Thought, mind and intellect appreciate it, give it form and consistency in its workings, attribute principles of law and order to it; but in this particular department of nature, there appears very little law and no order, simply because there is no mind to appreciate and recognise these objective qualities she possesses. We are still very far from that easily imaginable, though impossible in some things, conclusion of physical science—the abstract power of indefinite prediction. In consequence, we get nothing but effects, seemingly without cause and self-developed. 'The wind bloweth where it listeth; ye hear the sound thereof, but cannot tell from whence it cometh or whither it goeth'—words as applicable to meteorologists now as they were to the Jews of old. The same thing may be correctly stated with regard to storms. In spite of the undoubted progress of observational meteorology during the last half-century, nothing has been discovered that brings us nearer the goal we desire to reach, or to unite facts with reasoning. Nor has anything been discovered to render lunar

influence one whit less probable; the reasons and facts brought to disprove it are easily refuted and explained. On the contrary, it is rendered more probable than ever; right interpretation of the facts is the only thing necessary. It must be confessed that the proofs hitherto brought forward in support of this theory are somewhat vague and indefinite; yet, there are sufficient to establish a *primâ facie* case and encourage further observation. What is most objectionable is the absolute manner in which those who follow meteorology as a profession assert that the moon has no influence, doubtless, because they fail to discover it. The fact is, that the question of lunar influence is still quite an open one, and has never been decided either one way or the other; for it is impossible, for many reasons, to accept the observations already made as final. Seeing the confusion that exists amongst meteorologists, and the conflicting theories that surround this science, we seem obliged to fall back on the only true philosophical cause, the only cause capable of producing the effects we see and feel, and that is—the influence of the moon's attraction on the whole mass of the atmosphere as the earth rotates, and distributing the weather over all regions of the globe alternately by means of her change in declination and the position of new and full moon in longitude. Professor W. Ferrel writes :*

'The theory which attributes the whole of the barometrical oscillations to the rarefaction of the atmosphere produced by the condensation of vapour in the formation of clouds and rain cannot be maintained; for, according to that theory, in the rainy belt near the equator—where there are always copious rains during the day, which are succeeded by clear atmosphere during the night—the oscillations of the barometer should be greatest; and towards the poles, where there is little condensation of vapour into rain, they should be the least, but we have seen that just the reverse of this is true.'

A very high authority has thus written:

'The moon is often appealed to as a great indicator of the weather, and especially its changes as taken in conjunction with some existing

* 'Motions of Fluids and Solids on the Earth's Surface' (Washington).

state of wind, or sky. As an attracting body causing an aërial tide, it has, of course, an effect, but one utterly insignificant as a meteorological cause, and the only effect distinctly connected with its position with regard to the sun, which can be reckoned upon with any degree of certainty, is its tendency to clear the sky of cloud.'

And even this insignificant attribute of the moon is not by any means so certain as stated to be, for others say that there is really no ground even for this belief; that observations carefully made disprove it.

For practical meteorology, which consists in the prediction of the weather, the first thing to discover and determine is the cause which produces the fluctuation of mean values, and departure from mean conditions, and the irregular variation of the meteorological elements; the cause of storms and the law governing their progressive motion, also all peculiarities connected with them; the law governing the formation of anticyclonic or high pressures, also, if it be possible, some law of periodicity with regard to the barometrical maximum and minimum and their occurrence with regard to *time* and *place*. After this is known, we can proceed to a consideration of their value and statical force, and estimate the amount of the effects they will produce.

In the 'Phénomènes de l'Atmosphere,' by Monsieur H. Mohn, we find the following appropriate remarks:

'However, as we have already seen, the determination of the variation of atmospheric pressure is one of the problems that the science has not yet solved, and the prediction of the weather is reduced in consequence, in a great part, to an appreciation which is the result of experience, and which has for its principal base "un coup d'œil exercé," and the knowledge of laws which regulate the movements of the atmosphere. If we knew exactly these laws, we could, given the state of the atmosphere at a certain epoch, calculate its past conditions, and future ones, for some time before and after, and consequently predict the weather in the same manner that the astronomers fix the position that a star will occupy in the heavens at a given moment.'

Notwithstanding the favourable direction the science has taken of late years, it is very far removed from even an approximation to the accuracy of other sciences; yet in the opinion of Professor Mohn, it

would seem quite capable of strict accuracy; and, that if we knew the laws which regulate the atmospheric motions, the weather might be predicted with the exactitude of astronomical phenomena.

Captain Hoffmeyer writes, page 3 :*

'Il est vrai que le science pourrait à bon droit se refuser à ses exigences qui sont le moins très-anticipées, car elle forcent la météorologie à faire des applications à la pratique, pour lesquelles on manque encore de toute veritable base scientifique, mois une fois qu'à cet égard on est arrivé sur la pente des concessions, et que déjà de plus d'une manière la prestation a rendu service, c'est à peine si maintenant il serait possible ou habile de faire retraite et sous prétext de science, refuser sa coopération.' 'Tant que les météorologues admettront que la nature propre des purtabations atmosphériques, les causes qui les suscitent, les développent et les font disparaître sont des énigmes jusqu'ici sans solution ; tant que, capables de répondre seulement à la question : Comment ? il nous sera réellement impossible de résoudre la question du Pourquoi, il faut de toute nécessité concentrer toute l'importance du *service du temps* dans l'organization d'un system de renseignements aussi étendu et sérieuse que possible ; c'est un *service d'avant postes* qu'il faut établir : vouloir couvrir cet œuvre du manteau de la science, c'est à mon sens, une double faute, qui ne conduit pas au but qu'on se proposait en pratique, et par laquelle la science est compromise.'

This states the matter in its true light; meteorology has no true scientific basis, and, as for the particular phenomena called 'storms,' they are enigmas until now without solution, and extended observation alone, will scarcely lead to the end and aim for which weather departments were instituted. Foreign meteorologists seem more candid and frank in their statements than their English brethren.

It is generally admitted that we are without any certain knowledge of those external influences which are the principal causes of weather changes. Are these causes to be looked for in the heating action of the sun alone, and in the earthly phenomena which are generally supposed to arise from his influence, such as the weather, the force and direction of the wind, etc., combined with the effects produced by the unequal distribution of land and water; or, in some cause, less steady and equable, and working

* 'Etude sur les Tempêtes de l'atlantique Septentrional,' Copenhague, M. Hauberg et Cie.

over and above these disturbing influences, which only tend to mask, but not obliterate, primary ruling causes co-operating with them and attributed to the moon? But neither heat, nor the agencies and forces which act exclusively within the region of our planet, are capable of explaining the causes of the greater phenomena presented to our view. Up to the present no ray, ever so faint, comes to illuminate our path, and prediction of storms, which is the goal to which all our efforts should be directed, is as far removed as in the first days of the science. The public is quite right in expecting that the work of meteorologists should lead to some practical results, and especially with regard to those violent disturbances of the elements, storms, which in our islands work destruction and cause such immense loss of human life, property, and ships. Was it not the Bishop of Carlisle who moved for a return of the storms which had visited the British Isles between the 1st of January, 1874, and the 31st of December, 1883, and of which no warning had been issued from the Meteorological Office? He pointed out that in 1882 ten storms of which no warnings were given reached our coasts. This is a serious matter when we think of our vast mercantile navy and fleets of fishing boats in eastern ports. As for the daily weather forecasts, it does not seem people pay much attention to them, and as to their general accuracy, we can say nothing positive, not having taken the trouble to test them.

In the face of many drawbacks, meteorology has made much progress in an observational direction, and in that only; insomuch so that it seems high time to pass this stage and make a real advance. Some of these observations, made at a considerable cost of time, trouble, and expense, have resulted in useful and beautiful synoptic charts, such as those co-ordinated by Captain Hoffmeyer, covering all Europe, the Atlantic, and part of America. These charts show us at a glance the daily state of the

atmosphere over an extensive area, and they are invaluable to the meteorologist in his studies. There are also the charts co-ordinated by Mr. Buchan, which show the mean annual and mean monthly circulation over the whole of the northern hemisphere. These may be considered the key to the circulation of the air, and they have helped very much in the formation of the lunar theory. There are also the International American charts covering the whole of the northern hemisphere, except small portions of the Pacific and Arctic regions. It would be difficult indeed to imagine what more in the way of observations are wanted than those which exist already. We have had also, for a long time, isothermic, isotheral, and isocheimonal lines, together with charts of storm-tracks, wind currents, and others, all very useful and interesting. Lastly, though by no means least, there is the Ben Nevis Observatory, which, let us charitably hope, will furnish us with some great results one of these days. Nature has been questioned and ransacked in every direction, and all this is practical work in a right direction, as far as it goes; but, unfortunately it has added nothing to our knowledge of causes, nor do the compilers of these elaborate charts seem to have appreciated the full value of their own productions.

If lunar influence be not a myth, and does exist, these charts, which contain the chief features of atmospheric action, and which can be followed daily, ought to show it; and observations have proved that they do, and that in a very remarkable and decided manner, especially the charts of Captain Hoffmeyer.

With regard to the observations of private observers, and those which by this time must crowd the observatories, have any deductions ever been made with a view to throw any light on the question—the manner in which the science works? What law governs the formation of anticyclonic pressures and cyclonic depressions? Neither one or

the other, it has been stated, show any periodicity; yet, if anything is certain in meteorology, it is that weather changes are, to a certain extent, periodic, and are shown to be such by the barometric curve. The circulation of the atmosphere being in the form of anticyclonic and cyclonic movements, these determine the weather of the place over which they pass; and the reading of the barometer and thermometer, with every trivial detail, depend on these two great systems of circulation. The cause and origin of the anti-cyclonic pressures must be understood. As Dove remarks :

'Wherever two phenomena constantly occur together, we may with some probability presume that one depends on the other in the relation of cause and effect. But it will remain to be decided which of the two is the cause and which the effect, because it is not impossible that both phenomena may be the result of a third phenomenon ; nor, in fact, can it be at once decided whether when one of the phenomena is really the immediate effect of the other, the same result may not be brought about in a different way.'

It has never been stated what law governs these systems, or the configuration of the isobars on a weather-map; though it is these systems of circulation that force themselves on our notice at the very outset of our meteorological studies, and they are the most evident phenomena requiring explanation; not only as to their cause, but also as to the laws which govern their selection of certain places and change of place. The following remark by Webster is worthy of notice :

'Unless we can assign a principle of order to the winds, all we have hitherto said is in vain.'

Admiral Fitzroy also remarks in his 'Weather Book,' page 101 :

'A quarter of a century's attention to the subject since has convinced the writer that consideration ought to be given first to the great parallel currents, and afterwards to their consequences when disturbed, namely, storms, and other occasional phenomena.'

It may be said with truth, nothing is known about

the law which governs the pressure of the air, nor its movements, nor its evidently recurring periods. Anything seemingly more capricious than the barometrical curve it is difficult to imagine; its course cannot be predicted with certainty two hours in advance; an apparent absence of law and governing principle, appears to run throughout the whole of the effects that surround us, both on a large and a small scale.

Sir J. Herschel remarks, in his 'Meteorology':

'It would be no small discovery, if by the study of the characters and progress of barometrical fluctuations we could either make out any law of the greater ones which would enable us roughly to predict them, or any peculiarity in their physiognomy by which we could recognise them in their earlier stages, as by this means we might be led to the prediction of great storms."

In a pamphlet by R. S. Strachan, F.M.S., 1868, page 16, the author says, 'unfortunately, no such law is yet recognised,' nor, indeed, up to the present moment has anything been added to our knowledge of the subject.

And thus it is evident, meteorologists, even the most scientific, know not what law governs the atmospheric system; the whole is a riddle, an enigma, and a mystery. They are ignorant of the very first thing that presents itself to our notice —the barometrical curve; and also of the configuration of the two systems, anticyclonic and cyclonic, as represented on a weather map. Nothing is known about the laws governing their formation, culmination, period of duration, translation to other areas; and final disappearance. The storm-track changes its place from day to day, sometimes passing over our islands, at others passing elsewhere, but why or wherefore is a hidden mystery, and these two questions are the most important and require solution. Making observations is merely mechanical work, and we can go on doing this for ever without getting any nearer to a solution of the question.

'To unite reasoning with observation, and not

lose sight, at the same time, of the end to which the science should tend, and to find this end by experience, is the work of philosophy.'*

It will be granted that all observation should tend to predicting the weather, but to do this we must have a true theory. If we get at a principle, we get at wisdom—true weather wisdom, which, rising on the wings of prophecy, will pierce the future and tell us our periods of storm and tempest, of heat and cold. Of all the observations collected so laboriously, how many have been co-ordinated in any scientific order to arrive at this desired end? They are quite unconnected with any dynamic laws on a large scale, and there is not the slightest link between observed fact and philosophical theory, true or false. There is a principle in our nature which makes us dissatisfied with unexplained and unconnected facts, and we are naturally led to theorize all the particulars of our knowledge, and form in the mind some system sufficient to produce and explain the effects we see. We know that the beautiful phenomena presented by nature in the air and sky are connected in the relation of cause and effect, and we have an instinctive desire to classify, arrange, and refer them to some law of operation. The action of material causes can leave nothing to chance in the result. The atmospheric phenomena are constantly changing, and most complex in their action, yet they are all the effect of one simple law, so that a single drop of rain cannot fall to the ground, nor the barometer rise the tenth of an inch, without participating in the general law governing the whole. We are forced, from the nature of the case, to theorize, and try to discover some theory, and test it by application to the observed facts; and the sole real test of an hypothesis is its accordance with fact; and, assuming that the facts are properly established, it must agree with all of them. The lunar theory affords such an

* Du Vrai, du Beau, et du Bien, page 20, Victor Cousin.

hypothesis, and considered as the writer has considered it, the facts agree with it; there remain only a few residual difficulties to overcome.

It was remarked that observations are quite unconnected with any dynamical laws on a large scale, and that there is no link between observed fact and philosophical theory. Observations are surely ample and sufficient, and extended over an area large enough. The main features of atmospheric conditions are accurately known, with all those effects produced primarily by the sun's heat, and which occur in a comparatively regular manner. Yet if we look at meteorology as it really exists, it consists of little more than a miscellaneous collection of observations, more or less accurately determined—of means and averages compiled often without any end in view. All seem to have been co-ordinated without any consideration as to which of them would really be useful for the advancement of the science, and which superfluous. All cannot be of the same value. In the process of induction it could not but occur, that, in such a comprehensive science as meteorology, some facts would be of much more importance than others; some obscure, others easily interpreted; some only understood by reason of the light afforded by others correlated to them. This being the case, surely it behoves meteorologists to distinguish what Bacon calls the *prerogativa instantrarum*, or the comparative value of facts as means to the discovery of causes, and to discriminate between those particular facts which might, from the nature of the case under consideration, be supposed to form points of general agreement, and those which might, for the moment, be put on one side. Observations have been indiscriminately made in a way very ill-suited to discovery, and the result is that meteorology presents a valley of Jehoshaphat of the dry bones of statistics and observations, lying for the most part dead and useless. In the light of some life-giving

theory, or the spirit of genius, they would instantly become endowed with life and take their places in a harmonious system. Meteorology presents a confusion not by any means creditable to its professors. In all researches, as long as we have only facts, and these isolated—as long as they are not connected with some principle or law, we possess the principles of a science, but the science itself does not exist. Science begins where law appears. As meteorologists have not shown any connection to exist between observed facts and philosophical theory, nor is any hypothesis considered with a view to interpret the facts—and, as regards weather prevision, we are almost precisely where we were centuries ago:—is it any use going on any longer taking observations? Are not those already existing, amply sufficient to enable us to form some weather system, affording a clue to the laws which govern the winds in their courses, and, with them, all those beneficial changes which compose the weather?

That there is evidently some other agent at work besides heat is allowed by meteorologists; and when we consider what the effects of heat really are, and the phenomena we require to explain, it is beyond question that heat alone cannot satisfy the problem. It is undoubtedly one of the chief agents in producing the circulation of the air, the great primary cause of any circulation at all; but it is certainly not the great directing and controlling power. It is the first cause, without which there could be no circulation whatever, and without which all that at present exists in the science could not exist. But what is that mysterious agent which comes into play, and which eludes the grasp, and dispenses the sun's blessings to all nations of the earth? Let us consider the earth and sun alone in space, and no moon. The sun alone could create a tropical and polar current of air, and also, as his declination varies, cause a

translation of their limits and places of meeting in temperate zones, as he does in equatorial regions in the movement of the calm belts. These are effects distinctly traceable to solar action. Solar heat raises the waters of the ocean up into the air, and it is wafted away by the breeze to fertilize all corners of the earth, each in its turn receiving the benefit and the blessing. The disposal of land and water, of plains and mountains, might be considered to have considerable influence in modifying these currents of air. But considering, that the heat of the sun diminishes gradually from equator to pole, and may be considered as an unvarying quantity; also, that the geographical distribution of land and water does not change, it seems then, we ought to have a return of similar weather conditions every year, well capable of being predicted before hand, like the monsoons of India. For long periods, there would probably exist an unvarying circulation of supposed currents, with the heavens obscured by a perpetual canopy of cloud, similar to what does exist occasionally for some days together, until a break-up occurs, owing to the approach of a depression which disturbs this stagnation. There would be no fluctuation of the barometer as at present, except that due to seasonal changes. We should live in a region of settled trades, varied at well-defined intervals by some violent commotion due to the heat of the continent in summer. Such conditions would probably result if there were no moon to disturb the atmospheric currents. Admiral Fitzroy stated similar opinions in his 'Weather Book,' but they appear to have been forgotten. Heat alone accounts for much; evaporation, humidity, probably electrical causes, magnetism; but, it is far from satisfying the actual atmospheric conditions, and perfectly incapable of explaining the departure from those conditions. Storms travel over continents and seas alike, and at all seasons of the year. They traverse the American and Asiatic continent

alike, in both winter and summer, and in several directions, and appear to be but slightly affected by the contrast presented by the unequal surfaces of land and water, except as to their form. Anticyclones are not either dependent on land or seas, or on heat or cold; there is, without any doubt, some general law overriding any local cause, or even any terrestrial one.

The lowest area of atmospheric pressure is shown by the mean monthly charts to be in January, and during the winter months, a little to the north of Iceland in the Atlantic, and over the Aleoutian Isles in the Pacific. The higher anticyclonic pressures are, relatively to these low pressures, over Central Asia in the east, and the southern part of North America on the west. The mean circulation during the winter months is shown to be in the form of two great cosmical vortices in the northern hemisphere; and one in the southern, over the south pole; and the air that blows from equatorial regions flows into the centre, where the barometer is low, according to Buys Ballot's Law, and our islands are situated precisely in the most dangerous part of this vortex, where the isobars crowd together. By this simple means of representing to the eye a graphic delineation of the atmosphere's mean circulation, its actual circulation, in relation to this mean circulation, by the lunar theory, at once becomes apparent; and, it was owing to an examination of the mean form, given by the isobars, that the lunar theory was first suggested to the writer, and since corroborated by reference to the actual circulation as shown by the daily charts.

We must be careful not to be misled by these mean isobars, and it must not be forgotten that they represent only the mean circulation; the actual is far different, and the air, in fact, shows no such regularity as that which they represent. In the middle of the winter months very high pressures frequently cover the entire Atlantic, just

where the low pressures should be, and last a very long time. In February, 1875, a high pressure covered Iceland from the 16th to beyond the 28th, culminating to 30·512 in. on the 23rd, with the air turning out of it in a direction with the hands of a watch, and not against it, as the mean pressure shows the circulation to be. Low pressures often occur over the centre of Asia also during the winter months, with the air turning against the hands of a watch, just the opposite of what the mean pressure shows to be the case. On the 23rd of February the pressure over Iceland was, instead of 29·4 in., which is the mean of that place, an anticyclone of 30·512 in., and which remained with little variation for twelve or fourteen days in the same place, while the areas of low pressure were dispersed as follow: one in 68 W. long., 70° N. lat.; another 20° W. long., 28 N. lat.; a third over Spain, and a fourth at the North Cape; this latter having a depression of 29·331 in. Again, from the 19th of November to the 10th of December the same reverse conditions occurred; and on the 6th of December, 1875, the pressure was, a little to the north-west of Iceland, 30·709 in., instead of 29·40 in. The pressure over northern Siberia, where the high pressure should have been, was, on the 13th of December, 29·331 in., instead of 30·20 in.

If we take a synoptic chart covering more than half a hemisphere, quite different and opposite conditions from the mean present themselves. So far from being symmetrically divided into two vortices over the oceans with high pressure over the continents, the atmosphere, in temperate zones, is actually broken up into innumerable patches of different and very variable sizes of anticyclonic pressures, which sometimes, when large and pretty regular, may enclose several high pressures, yet relatively lower, within it; but, in some two places, generally two to four, on the earth's surface the high pressure culminates to its highest point. There is to be seen also

a large area of low pressure, enclosing within it several smaller areas. Sometimes it forms an irregular zone, containing several depressions; sometimes it is a large irregular nucleus, which becomes deeper or fills up; and, as to the place of its development, it may take place over the land or over the seas. There may be, when the air is very disturbed, as many as eight or ten independent centres of depression forming the whole; at other times, they are dispersed far apart, and appear totally independent of each other. The high pressure at the edge of the tropics, instead of being situated in 28° N. lat., often extends during winter months much further north, sometimes to 40°, and unites with the high pressure of the continent, and frequently takes an oblique direction across meridians. These are knotty points which do not coincide with the usual theory, and which meteorologists avoid and give no interpretation of, but are naturally connected with that law which causes the departure from mean conditions. On the lunar theory they are perfectly intelligible, and the extreme opposite states of circulation are obliged to occur *where* and *when* they do, in obedience to an inexorable law, depending on certain positions of the sun and moon at stated times relatively to the earth's surface; and each satellite depression contained within the larger area of depression has its appointed place, and travels in a certain direction, which can be known beforehand and depended upon. When we look at a synoptic chart covering a large surface, it really seems that no law or order prevails. Owing to the extreme mobility and elasticity of the air, which is free to obey the slightest impulsion (for a small difference of pressure suffices to generate a considerable wind), it is always seeking equilibrium, yet never gaining it. And, again, being deflected by the earth's rotation and terrestrial influences, the simplicity of the sequence is further destroyed, and this is one cause of the complexity and irregularity of the phenomena

we perceive. And if this were not enough by itself, another cause comes into operation which changes the whole circulatory system at a mean of 23½ degrees to the axis of the earth, and again augments our difficulties in tracing any law or principle; nevertheless, the law is there, and it is omnipotent, and overrides the effects of the geographical distribution of land and water and all local causes.

Gravitation is one of the keys with which we can open the secret store-houses of nature.

M. Quételet, in his 'Treatise on Periodic Phenomena,' remarks:

'Astronomy, and particularly the observation of the two great luminaries that strike our gaze the most, may be considered as including the origin of all the phenomena that deserve to engage our attention.'

Indeed, it may be that variations of the atmosphere, and those of terrestrial magnetism, will eventually be traced to the same cause; and, the moon's influence once established over the weather beyond doubt, we have a key to both, the latter depending on the former, and both probably on solar and lunar influences. Certain curious coincidences have appeared which tend to support this. It is just possible that the atmosphere itself is the seat of magnetism. Faraday proved that oxygen is magnetic, and oxygen forms more than one-fifth part of the atmosphere; and if the moon directs the atmospheric currents; magnetism and its effects, as far as it regards the air, would receive a certain explanation. Changes in the electrical conditions of the air occur *with* changes in the weather, and it is probable that the atmosphere's electrical condition is owing to an external cause and not an internal one. The force of gravity is an incomprehensible existence. We observe certain laws with regard to it, but what it is in its essence we do not know. Faraday thought it was connected with magnetism, and that it was capable of an ex-

perimental relation to electricity, magnetism, and other forces. From the lunar theory it appears that it is the atmosphere which is the seat of magnetism; for though the first primary system of wind circulation can be traced to the moon's influence, the other systems cannot; they appear to be the results of the first, and they, in their turn, cause others. But how? Lunar influence cannot be made in any way to account for them in a direct manner. It appears there are gyratory overlapping systems, revolving, or with tendency to revolve, round other systems; in fact, a sort of terrestrial astronomical system, which in the want of some better interpretation would appear due to magnetism.* The study of these revolving systems over the earth's surface, and their obedience to law, as shown by the depressions, is most curious, and opens up questions of deep interest and importance, not only to meteorology, but for terrestrial magnetism and magnetic storms as well; it seems in some way to point to an intimate connection between attraction and magnetism, and opens up a new region of scientific speculation. It must be remarked that storms appear to arise from the contact of the systems of wind circulation, and then revolve round the centre and with the system. But on any magnetic theory *alone* we are as far from any explanation as on any other of the theories; but, admitting the moon's attraction on the air, we have a force which acts, and according to known laws, the effects of which can be brought within the realm of mechanics and calculation.

* These larger gyratory systems are distinct from the storms they contain in them, and *appear* to unite or recede from each other at certain times, according to some law of attraction or repulsion. Indeed, it appears that the atmospheric circulation is in the form of several large rotatory systems or whirlpools, which, in their turn, create others and have the power of attracting and repelling each other.

Sir J. Herschel writes ('Meteorology,' page 5):

'And hence arises one of the most marked peculiarities of this our science, viz., that while in respect of the general explanation of its phenomena it may be said to be nearly complete, inasmuch as there are few of its more important facts and broad features which cannot be rationally and satisfactorily accounted for, and referred to the recognised operations of physical agents, yet when we would follow out the results of their actions in "number, weight, and measure," and as exhibited in specified time and place, theory affords us little or no assistance.'

Herein lies the essence of the subject: to follow out the result of the atmospheric actions in *number, weight,* and *measure,* and as exhibited in specified *time* and *place.* If it be possible to do this, we must have a knowledge of the cause of anticyclonic and cyclonic systems and their governing law, and consequently, we ought to be able roughly to project the barometric curve for any given place; also great storms could be predicted. Before, it was remarked that the prediction of great storms depended on making out some law of the greater barometrical fluctuations by a study of their characters and progress, and so, by this means, we might be able to 'recognise them in their earlier stages,' and 'possibly be led to the prediction of great storms.' In 'Principles of Weather Forecasts,' R. Strachan, F.M.S., the writer, in speaking of the above quotation from Herschel's 'Meteorology,' remarks:

'Unfortunately no such law is yet recognised; and though it has been practically proved by Admiral Fitzroy that great storms can be predicted from one to three days beforehand, in the present state of meteorology, still there can be no doubt that accurate weather predictions would result from the knowledge of this law, if there be such a one in nature. The existing records of atmospheric pressure furnished by barographs have not yet been investigated with the care necessary to throw light on this subject; it is a work requiring much consideration and immense labour. There can be no doubt that the records of self-registering barometers during the next ten years will be of the utmost value to meteorological science, especially in the investigation into the laws of the fluctuation of atmospheric pressure; and it would seem that observatories situated respectively at the centre and extremities of rectangular co-ordinates (so to define it) would be best disposed for the inter-comparison of results.'

This was written in 1868, and the last seventeen years have brought us no nearer to this discovery, which would, indeed, be a grand one. Have the 'barographs' been investigated which are to throw the desired light on the subject, and have the self-registering barometers been of any value to meteorology at all? We do not think any investigation of the past barometric curve will ever throw any light on the law governing it, because there is no cycle, except, probably, one of some thousands of years, in which the weather repeats itself with the accuracy sufficient to cause a return of similar conditions, and that would produce a return of the barometer curve over the same place. Any search for such a cycle of curves is waste of time and labour; we should always be confronted with the same irregularity, and only partial and broken cycles. That there is such a law in nature is pretty certain, but probably it recurs in a cycle of immense length, and extends back to periods when barographs were unknown.

It may be safely said, that meteorologists generally promise us 'great results;' each new idea or scheme is always to furnish them in a certain number of years. Unfortunately, these great results are pushed farther into futurity, and each advance, instead of bringing us one step nearer to the goal we desire to reach, leaves us as far off as ever. As time advances, the great results invariably recede into the 'dim, dim distance.'

II.

Storms: Their Anomalies and Peculiarities.—Want of some True Theory of the Weather.

A few words about storms may not be out of place here, for they are the most obvious results of the moon's action, and also the most terrible and disastrous in their effects.

It has been stated that the cyclones of the Indian Ocean are more frequent and possess greater energy during years of maximum frequency of sun-spots. A good deal might be said about this theory, but space will not permit.* It is just one of those coincidences which appear for a while, but after a short time will disappear and be forgotten.

It has been noticed that in the temperate zones of the United States, during the northern declination of the sun, the mean track of storms lies further to the north than during the southern declination. That storms have been traced from Newfoundland to the British Isles is affirmed by some and denied by others. Martin, in his 'Rotatory Theory of Storms,' believes he has traced numerous storms over the Atlantic to Great Britain and continent of Europe. Captain Hoffmeyer states that during the period of twenty-one months there were 285 minima observed, and he has thus traced them:

23 appear to come from Baffin's Bay or Davis Straits.

* It may be briefly stated, that it is highly improbable the periodicity of sun spots will ever enable us to predict the weather, or even seasons, in advance.

126 from United States of America and Canada.
25 from between Newfoundland and the Azores, probably from the tropical regions of the Atlantic.
106 from the middle of the ocean, by a segmentation of storms already existing, and in consequence are called partial or secondary minima.
5 appear to be formed spontaneously—*au large.*

It appears that the season makes but little difference in the number of storms. Winter gives a mean of 42; spring, 37; summer, 35; autumn, 45; and that during the summer more than half are produced in open ocean in the form of partial minima.

He also remarks that only about the half of these storms, or 145 out of 285, exceeded 10 degrees to the west of Greenwich. Speaking of the 126 storms which traversed the United States and North Canada, he says:

'En seconde ligne nous voyons que les minima de la catagorie B, qui émanent des Etats Unis et du Canada, jouent un grand rôle dans les conditions atmospheriques de l'Europe, en sorte que l'importance attachée à ces phénomènes par les Américans est jusqu'à un certain point fondée; mais d'autre part les chiffres montrent que la somme de ces minima atteint seulement 47% c.a.d., ne s'élève pas même à la moitié du nombre total des de tempêtes que l'ocean Atlantique déchaîne sur notre continent. De même aussi, des 126 minima qui partent de l'Amerique septentrionale en franchissant le 60° de longitude à l'ouest du méridien de Greenwich, seulement 68 ou environ la moitié atteignent l'Europe. Ainsi donc tant qu'on ne pourra point se procurer d'autres auxiliaires rendant possible l'investigation des routes de mer suivies par les tempêtes, l'incertitude restera trop grande pour que les renseignements d'Amerique rendent à l'Europe des service particuliers.'

Thus it is shown, that of the 126 storms that left America for our shores, only 68 reached Europe, so that storm-warnings from that quarter are not of any particular service. Nevertheless, it is useful to know when there is a probability of any dangerous storm reaching Western Europe, even if its direction cannot be defined.

Depressions enter the United States from the Pacific and travel entirely across America, but in many cases the Rocky Mountains are a barrier sufficient to destroy their force. Others enter the United States from the British possessions near Manitoba, and these in general move over the Lake districts.

The plateau of the Rocky Mountains seems favourably situated for the development of storms. A storm sometimes begins and ends in the United States, but this is rare. Storms also travel from the British Isles to St. Petersburg, and on to the White Sea. They cross Scandinavia from the North Atlantic to Finland, cross the Ural mountains and pass on to Siberia. Very many come from America, crossing the Atlantic between Iceland and north of Scotland, and go on to Arctic regions. Frequently they come down over Siberia and Asia from N.W., and come up from the Mediterranean to Black Sea and Russia. It would be difficult, indeed, to say in what direction they do not come—in every direction, except against earth's rotation, though they occasionally back against it for a short time.

These gyratory motions of air, or storm depressions, travel from the Atlantic to our islands, and sometimes much further; and it is rare to find them entirely suppressed in the Atlantic; yet sometimes this does occur.

The mean track lies to some point in the N.E. Mr. Buchan says:

'Several storms have advanced on Great Britain from N.W., still more have come from W.N.W., and W.; but the larger proportion appear to come W.S.W. and S.W., and advance towards E.N.E. and N.E.'

Mr. Scott writes ('Weather Charts and Storm-Warnings'):

'If then, these disturbances are frequently travelling in succession over the Atlantic, it is evident that we on these islands must at times encounter a series which bears a close resemblance to a series which

has preceded it, as to the general character of the areas of depression themselves, and as to the intervals which occur between them. This we have noticed in our own weather on various occasions, and the parallelism has been found to hold good for as many as eight days together. Here, then, is a most promising field for further inquiry, which it is hoped will eventually be carried out.'*

At page 90 the same writer remarks, speaking of the depressions and their relative bearing to adjacent anticyclonic pressures :

'These areas of low pressure will follow each other until, by *some means or other* [the italics are ours] the excess of pressure in the west has been reduced.'

Now it is just this question of the 'means,' and the absence of any positive knowledge as to its nature, that is at the basis of the whole science. Once it becomes known, our meteorological difficulties will be exceedingly reduced. The storm-track changes its position daily, sometimes passing over our islands, sometimes elsewhere; and there may be several different storm-tracks over one hemisphere at the same time. The storms they contain are more dangerous and violent over the ocean, from which region they generally first strike our shores, having lost but little of their energy and force, and even often come to us with energy increasing. However, it is possible for depressions to be suppressed for a long time, even nearly a month, over our islands; but this is rare.

We see these storm depressions come from every point of the compass, and travel over seas and continents alike, though not with the same force and intensity. With regard to their origin, nothing is known with certainty; the specific conditions out of

*It may be remarked, that seven or eight days is half a lunar cycle, and is the time occupied by the moon in going from the equator to her extreme declination. More than 3000 observations have placed it *beyond any doubt whatever*, that, when the declination of the moon is represented by a line round the meteorological pole, at a distance from it equal to her declination, there, the storm track will be found. When the circle so drawn comes over or near the British isles the storm track passes over or near us. This *fact* alone is sufficient to establish the moon's influence.

which they take their rise are involved in mystery. There are numerous theories with regard to them which we cannot consider here.* Mr. Scott remarks, speaking about the different theories held with regard to storms:

'It is clear that when "doctors" differ to the extent indicated in the above sketches of the different theories, the world in general must be content to wait patiently for a complete theory of the weather to be developed.'

The most natural cause of them would appear to be that indicated by Mr. Meldrum, who considers storms to be generated in the space intervening between two currents of air which are tangents to the nascent cyclone. Between two winds and forces in opposite directions, there would naturally be a tendency in the air between them to assume a gyratory motion; and, we might imagine that, as, the forces which produce these winds, upon which the gyratory motions depend, increase or diminish in intensity, and also their angular distance from one another; so, we may imagine the storm to correspond, in a certain manner, to these forces—increase or decrease in size, get deeper, or fill up and disappear. Yet it cannot be affirmed that storms always originate between two opposing currents of air; for observations seem to point out that they are developed where no such conditions exist, or, at least, are not shown to exist by instrumental observations. The observations of the author point to two periods when storms have a tendency to develop: extreme northern or southern declination of the moon, and when she is crossing the equator; but this cannot be affirmed to be always the case, for observations undertaken with the particular object of noticing *when* storms are developed with regard to lunar positions, have been too few to lead to anything positive about this. Nevertheless, it seems that they are developed frequently by a change in the

* 'Weather Charts and Storm Warnings,' R. H. Scott, M.A., F.R.S.

direction of the force which directs the currents of the atmosphere, and the earth's rotation acts as an opposing force to this change. But the question remains, What is that force, and where is it to be found?

We must notice what Captain Hoffmeyer remarks about storms:

'Il doit donc arriver de deux choses l'une: ou bien c'est une puissance exterieure (telle que la rotation de la terre autour de son axe) qui imprime aux perturbations un mouvement vers l'est, ou bien ce sont les perturbations mêmes qui par suite des formes particulières qu'elles affectent, developpent une force qui les déplace vers l'est.

'Pour comprendre cette dernière acception qui est bien le plus générale en météorologie, il est cependant nécessaire d'examiner de plus près les formes sous laquelles se produisent les perturbations. On distinguait précédemment les mouvements de l'air en direct et giratoires, admettant que les premiers caractérisaient surtout les zones tempérées et les zones glaciales de la terre, les derniers l'espace intertropical. A mesure qu'on a obtenu de meilleures cartes synoptiques du temps, couvrant sur la surface de la terre des aires suffisamment étendues, un fait, s'est pourtant révélé, savoir qu'il n'existe aucune distinction à ce sujet, mais que les mouvements de l'air sont partout déterminés par les repartition de la pression atmosphérique et suivent la règle bien connue que Buys Ballot a établie.'

The distinguished meteorologist observes, with reference to the remark about the storms developing a force which carries them to the east, that it is necessary to examine the 'forms' by which the storms are produced. He divides motions of the air into 'direct' and 'gyratory', and, admitting, that the first characterize temperate zones and arctic regions, and the latter the intertropical, actual observations of extensive synoptic charts reveal the fact that there exists no such distinction; but the motion of the air is determined by the division of the pressure, and follows the law known as Buys Ballot's. It is a fact that every disturbance is brought about by an unequal distribution of the pressure, so that the barometer is lower or higher in certain portions of the earth's surface; and the higher pressure may be regarded as a statical force pushing the air towards the centre of low pressure, to which it flows in a spiral manner. If the motion seems direct, it is

because the eye does not take in a sufficiently extensive surface in order to recognise the rotatory movement, or that several gyratory movements act, one on another, in such a manner as to destroy, in some places, this motion.

It has been pointed out before, that the actual atmospheric circulation is by no means like that represented by the mean circulation. By this latter synoptic representation, one might easily imagine the wind to be direct and not gyratory, supposing an observer to be placed in any portion of the gyratory system; but, viewing it from the outside, its really gyratory character becomes evident. Thus direct currents are only portions of large gyratory systems, or of the anticyclonic systems from which the air flows out and not in. Storms and relative depressions do exist between two anticyclonic systems; and they tend to proceed on a course round these systems, or sometimes even towards them, and influence them considerably in many ways; so much so, that, if there were no other means of knowing when a storm is approaching, the preceding effect on the then existing anticyclone ought to forewarn us. There is a change in the configuration of isobars, and certain well-known changes in pressure, and particularly temperature and vapour, its elastic force. There is, then, no such state as a direct wind blowing from Pole to Equator, or the reverse, as in the usual theory given to illustrate atmospheric circulation. On the solar heating theory alone these conditions should exist, and would most probably do so, but the moon introduces an orderly succession of changes, occurring fortnightly and monthly over different parts of the earth's surface each lunar fortnight; probably near to their preceding place or perhaps far removed, and this irregularity produces again the seeming disorder to an observer in any given spot. If the new moon returned always to the same geographical position, and at the same

distance each revolution and solar condition remained the same, there would be a return of absolutely the same weather, but this is just what the lunar cycles, it seems, are arranged to prevent, for our well-being and that of all nature. Strictly speaking, there can be no 'direct currents' in temperate zones; how, then, gyratory motions to any great extent, when it cannot be shown by the actual facts that the conditions exist necessary to create them? This would seem to be a case where certain conditions must be presumed to have existed, or to have a tendency to exist, in order to account for those actually occurring. It can be imagined that there is a *tendency* in the air to flow in parallel currents obliquely across meridians, and over certain portions of the earth's surface as superposed currents; and the former, particularly at certain times, when lunar and solar positions so unite in *place* and *time* as to induce to these conditions, reproducing something like the mean circulation in actual fact; and observation agrees with theory in this view of the subject.* If the air always showed such a circulation as the mean isobars exhibited, such system might be accounted for by the supposition of parallel currents flowing directly from Pole to Equator, and *vice versâ*, one over the seas, the other over the land, and containing a large gyratory motion between them. Such system might be attributed to the sun alone, but that which is the daily actual circulation, requires the intervention of some other cause quite different from that of solar heating influences. A system of circulation like that shown by the mean monthly charts, would, from the action of some external cause, like that of the moon's attraction, varying in intensity and declination, in relation to a rotating body like the earth, stable, and with its axis of rotation at the

* These periods appear to be when the moon is on the equator, especially when the sun is in the same position. The stormy periods occur immediately before or after.

same angle of inclination for the period of a lunar month, introduce exactly such actual conditions in the configuration of the atmosphere, as those shown by an extensive synoptic chart or map, viz., a breaking up into innumerable patches of high pressures, and their concomitant areas of depression; both, of every imaginable form and size, and seemingly without any order amongst them as to their place and time of occurrence, with the wind showing no very direct tendency to move in straight lines. Direct parallel currents, slowly or violently thus set in motion, in opposition to another force, like that impressed upon them by the earth's rotation; would, we may suppose, take every conceivable form, cause the complexity we see, and set up gyratory motions between them, and again the gyratory motions between each other. The complexity resulting from such intermixture seems to us disorder; but actual disorder in any department of nature is to imply absence of *law*, and that it is quite impossible to admit for one moment.

Captain Hoffmeyer admits it may possibly be an exterior power, a more general cause, such as the rotation of the earth on its axis, which impresses on the rotatory depressions a movement towards the east; or, it is the depressions themselves, by reason of the forms they affect. The depressions themselves cannot develop any force tending to carry them onward; nor, is it quite clear that their direction is entirely determined by the distribution of the anticyclonic high pressures, for sometimes the low pressures proceed towards them, and push them away as if they were in the way of the storm's predetermined path.* The rotation of the earth alone will not account for the storms recurving, remaining stationary, their collision, and other peculiar motions observed. That

* This insignificant fact of storms sometimes proceeding directly towards anticyclonic pressures seems to point to some exterior power as the directing cause; and, also, that anticyclones are *secondary* conditions.

it is an exterior power is the truth; but an exterior power which affects the whole mass of intertropical air unequally as the earth rotates; which, philosophically considered, is sufficient to cause the whole of the phenomena observed, and supplies a theory which unites facts and reasoning in the most remarkable manner, and also forms a most harmonic synthesis of all the conflicting facts and elements into a system, having its truth exhibited by the fulfilment of the predictions based on it.

It was remarked that storms always indicate their approach by their effects on the anticyclonic pressures. Before the appearance of a storm on the shores of Scandinavia, the elasticity of vapour and temperature increase at some distance towards the south from the place of the storm.*

'That with the progress of the minimum both denominated elements keep more or less the same position relatively to the minimum; and that the curves which represent the modifications of the elasticity of vapour and temperature almost coincide with one another.'

This subject has been treated of at length by Lieutenant Baron Maydell in a very interesting and instructive little paper. He shows that it is quite possible to define where the centre of the storm will be on the second day. If it is possible to know where the centre of a storm will be on the second day after its appearance, we shall be able to tell the direction of the wind and the character of the weather over a more or less considerable extent.

Ferrel also writes:

'It must not be supposed, however, that the progressive motion of cyclones depends entirely upon that of the air in which the cyclone exists. It depends also very much upon the direction in which the greatest humidity of the air lies. The progressive motion of the

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* Paper on 'The Definition of the Path of Storms as shown by the Modification of the Temperature,' Lieutenant Baron Maydell, St. Petersburg.

cyclone is generally greater than that of the air, even in the upper regions, and consists rather in the continual formation of new cyclones a little in advance of the old ones, the latter gradually subsiding, and this new formation is likely to occur in the direction of greatest moisture.'

This theory is, it seems to us, applicable only to those storms which come from America and traverse the Atlantic; but with regard to storms going from a moist climate to a drier one, as, for instance, to the centre of Siberia, is a similar relation between the way of the storm and humidity found?

The low barometer in the centre is well known to be owing to the precipitation of moisture, and it seems probable this condensation takes place chiefly in front of the storm, and, so to speak, draws it on. Heat is liberated and carried upward; the air turns to the centre, for the precipitation has caused a centripetal force to be set up, which the contiguous air obeys. The air in the centre rises, and other air flows on to take its place. All this time the nucleus moves on with the whirling mass flowing spirally round and into it; but this onward motion may, very probably, turn out to be only the motion of a state, and not an actual bodily progression forward. How far this is the case is not decided. They have also a centrifugal character, which all revolving bodies possess; and, probably, from this cause the barometer falls while influenced by the first portion of the storm.* The barometer rises again during the latter half.

Maury considers the low barometer to be owing, in part, to two causes. He says: 'One is the condensation of vapour, with its liberated heat, as

* The rotation of the earth acts as a deviating force on a particle of air. It acts perpendicularly to the path of the molecule, and makes it move to the right in the northern hemisphere and to the left in the southern.

The centrifugal force acts both as a deviating and motive force on those molecules which move in a curve, and tends to pull them from their path in the direction of the tangent. The direction of the molecule is the sum of these two forces. This subject is treated of and explained very clearly in Professor Mohn's 'Phénomènes de l'Atmosphere' (J. Rothschild, Rue des S. Pères, Paris).

maintained by Epsy; the other is the action of a real centrifugal force;' and he rightly considers that the flow of air into the vortex is retarded by centrifugal agency. It is curious to notice how storms receive often an increase of energy, and suddenly develop their force, and dart forward also unexpectedly.

With regard to the development of storms and their progressive motion, Thom remarks:

'Whether the opinions which have been advanced regarding the formation of rotatory gales approach the truth, must in some measure depend on future observation; one point, however, seems to be satisfactorily ascertained, that they are generally developed in the interval between what we may be allowed to call their parent winds, and in intimate relation with both, and in such a manner that each would convey additional impulse to the revolving mass at the opposite sides of the circle. In this manner a storm may be supposed to receive accessions of impetus at the exterior of the circle, by the conversion of the rectilinear force into a circular motion, and by enlarging the sphere of its action it would impinge more extensively on neighbouring winds and receive a continuous support. Even if the contiguity of two winds is not required to form a rotatory motion in the atmosphere, it appears to be absolutely necessary for the continued existence of such an action.'

Gyratory motions are generally produced in the interval between their parent winds, and in intimate relation with both. This is precisely what theory indicates, and what is shown to be the case by the two systems which the lunar theory causes to exist in the northern hemisphere, the extremities of which come in contact with each other at the exterior of the circle enclosing them; and in such a manner, storms might receive accessions of impetus by conversion of the rectilinear force into a circular motion. This cause may, indeed, be sufficient to account for the origin of the storm.* These conditions are

* Observations do not entirely support this theory. The author has frequently observed storms to develop where there are no indications of opposite currents. But how then is their development caused? May it not be caused by a change in the direction of the primary acting force guiding the whole atmospheric system, and which communicates to the winds, over a certain place, an abrupt change in direction relative to the earth's rotation in a uniform direction?

absolutely necessary for the continued existence of the rotatory storm, if not for its development; for it is found, on comparison with synoptic charts, that as long as the two systems impinge on each other, so long can the area of depression be clearly traced; and when they tend to separate or coincide with each other, the storm has a tendency to disappear. The primitive impulse or impact of the parent winds, which gives birth to the cyclonic movement, would not suffice to cause a storm to last for ten or fourteen days, without some constantly acting force to support it during that period. The precipitation of vapour in the storm's centre, is an effect of that force and impact, and its motion seems to be the motion of a state, and not a bodily progressive motion; and it can continue for thirteen or fourteen days. Thus, the large areas of depression, as shown by the synoptic maps, have, frequently, a very irregular progressive motion. They also undergo an expansion and contraction in latitude and longitude, and may last for a long time without any very great apparent change of position, usually from about six to seven or eight days, although there are indications that their longer period is from thirteen to fourteen. During the first of these periods their *form* may undergo great changes, while it may not alter its locality very much. This change of form appears to be caused by the gyratory systems it contains, and which pass on its southern and south-eastern side to east or north-east; but not altogether from this cause; for it appears, also, the change of the moon's declination has a power in this respect. The gyratory depressions which are contained in the larger area do not seem to have been caused by any conflict of two winds, and they follow each other, for from six to eight days, much in the same *direction;* but, at the same time, showing a change in latitude, obliquely across meridians. We stated that the motion of the larger areas corresponds to the change

of the moon's declination. It frequently does, but the assertion requires some modification. With such a depression as that noticed at page 62, which began on January the 19th, 1883, and lasted until the 29th or 30th, very little correspondence with the moon's motion in declination will be found; and, as to the storms, or gyratory motions of air, it may have contained, nothing can be affirmed, as we have not had the opportunity of examining more detailed charts of this period. But, with regard to those large areas of depression which have passed over or near the coasts of western Europe; it has been remarked that, while the large area, taking it altogether, shows some slight obedience to the law, the storms it contains do correspond, and frequently very accurately indeed, to it. Thus, though sometimes the larger areas may change but little their position, yet they appear to receive accessions and reinforcements of wind force, and new development of storms, succeeding each other for a certain period of time, which is half of our lunar cycle of a fortnight. It really seems that the larger areas require the conflict of two currents for their origin, and also to sustain them for a lengthened period of time, but it does not seem that the smaller ones depend, for their development, entirely on such conditions. Theory points this out, and facts seem to coincide with it.

Theory points to a lunar fortnight as the period of the larger depressions, but the modifications they undergo during this period so changes their aspect, that it is exceedingly difficult to trace them as one and the same depression for the whole of the fourteen days. The great and principal day of change in *direction* of the whole atmospheric system is when the moon is on the equator; after that, the day of extreme north or south declination. On the former of these days, the circle from the terrestrial pole, round which it is believed storms circulate, subject to the influence of the earth's rotation and centri-

fugal force, takes an entirely new direction to the east or west of its former position, and with it the direction of the storm-paths.

Moisture always exists in the air to a greater or less amount, and might always so remain there, unless the air was disturbed continually by the action of some agent acting on a large scale, and which brings the 'parent winds' in contact; for it is impossible for local causes alone to produce the immense phenomena often seen at all times and seasons. The revolving storm is fed by its parent winds, in probably different electrical conditions, and having different temperatures, depending on the regions from which they come. As we maintain that the larger areas of depression seem to obey a law with regard to the declination of the moon, and are traceable for a fortnight, while the storms they may contain follow each other for a period of from six to eight days, with perhaps little variation, it follows that the region of the precipitation of moisture in the centre of these storms, and the increase of temperature and elastic force of vapour in advance of their path, depend, not altogether on terrestrial and local atmospheric conditions of the surface over which they pass, but on the direction the acting force takes, which guides and directs the parent winds of which they are for the time composed. These winds have their own specific properties of humidity or dryness, temperature, etc., and cause certain changes in advance of the storm, which may be found to bear some definite relation to the advance of the minimum; but they can scarcely be the cause of its advance, although they may serve to predict it. There is, probably, some higher law upon which these things themselves depend, and which is the primary cause of the storm's progressive motion, and which is necessary to sustain that motion. It would also appear that the cyclonic systems are the first obvious result of lunar

action, and the anticyclonic systems the second, and that the flowing of the air from the latter to the former is the natural result of the precipitation and vacuum caused by a meeting of two winds in contiguous systems. The satellite depressions follow another law: these observations apply only to the larger areas of depression.

This theory might be made to explain very much more than is here stated, if we suppose that the real acting force drawing the storm on proceeds from a continuous action in the intertropical zone, propagating its influence through and by means of the anticyclonic high-pressures. But a further development of it cannot be carried out here.

It must not be forgotten that we have to consider a varying force, which culminates when sun and moon are in a line with the earth and the moon in perigee; and a force exerted in proportion to 'time,' an important element in all consideration of results. Time is an element in every change that can take place in the state of any one portion of matter, and in the producing of equal results, it is inversely as the power or energy of the agent by which the result is brought about. The product of the energy of the agent, by the length of time necessary, is the expression for the change that is to be performed. It is always well to bear in mind these general laws in the consideration of physical studies, for by ignoring or forgetting them much confusion is wrought. Those who understand the moon's motion know how irregular that motion is, and that, from one phase to another, differs considerably in time; so that, when it is proved she does affect the air, this is of paramount importance. It is also a cumulative effect, increasing daily over one place or area until the moment of new moon. However incomprehensible this may appear, observation proves it to be the case. It is, however, scarcely fair to make statements without accompanying them with some

sort of demonstration or reference to facts, so that others can be judges as well as the theorist himself; for theorists are very apt to be misled. We have endeavoured, however, to guard against any conscious error.

The supposition of lunar influence has been broadly stated to be absolutely inconsistent with the progressive movement of the 'weather' across the country from west to east,* which Admiral Fitzroy demonstrated to be the case, and upon which truth weather forecasts are based. He says :

'Without a general, lateral, or transmeridional movement, or translation of the atmosphere towards the east in temperate zones, but westward in the intertropical regions, in addition to meridional movements from and towards the poles, it would not be possible to forecast the character of wind or weather beyond one day's interval.'

So far from this eastward translation being any argument against lunar influence, theory actually insists upon it, and is in the most perfect accordance with it; a fact we shall show in a further work on the subject. It is also no argument against this influence that no periodicity has been observed in the recurrence of storms; for, from certain causes, no periodicity is permitted to exist for any given place, except in the vaguest manner, and for a time only. A certain periodicity has been observed in several of the meteorological elements; but it disappears as though the cycles became broken, or their effects negatived by another and longer one, only to return in their unity of action after, perhaps, an indefinitely long interval. But the disappearance of any continuity of action is absolutely necessary to the theory; it is the 'missing link' but which has its obvious reason. Nor is it to be expected that any change whatever will recur regularly with any position or phase of the moon, except in a vague and indeterminate manner. That there is an accordance of this description has been shown by observations, for ob-

* Professor Young, *Popular Science Review.*

servers have traced a relation between the phases and their influence on the rains and direction of the wind, but impossible to trace perfectly, probably on account of masking causes, by any rational train of cause and effect; but altogether the subject requires much more attention than seems to have been bestowed upon it. If it were possible to trace each separate phenomenon to a lunar phase, or new or full moon, it would have long ago been done. Why it is that the idea of the moon's influence has taken such a firm hold on the popular mind, would appear to be from a very long connection (extending, perhaps, through an immense period of time) between the general character of the weather and her phases; and which has, by hereditary testimony, taken the form of 'intellectual intuition.' It certainly seems she has a dynasty in men's minds which does not perish, and it will be a curious circumstance if, after all, it is proved to be the truth.

Imagine a revolving storm, whose progressive motion continues for seven or eight days, and might do so for twelve or fourteen. It would thus, in the first case, strike a vessel at the time of new moon, moon on the equator, first quarter and in perigee with declination north or south, and cause, each successive day, every variety of weather over the regions it has traversed, and thus to vessels along its path the change would come at any of the periods mentioned; but to which phase or position are we to attribute the change? Within its area, all kinds of weather must have been experienced at each phase, having no very great difference from that between the phases or positions, and high barometer and fine settled weather may probably have existed for the whole of the eight or fourteen days elsewhere. Any attempt to attach the weather disturbances caused by lunar action to any particular position of the moon has hitherto been attended with very little success. These things, however, can scarcely be brought forward as proof against her

influence, by any person who has paid any attention to the effects that would be produced, given that she does actually exert an influence on the air; for they are precisely the difficulties which, from the nature of the case, we should expect to find.

In temperate zones, storms may and do originate anywhere, and travel alike over land and seas, the geographical configuration of the former influencing them comparatively slightly, until they advance far over the continent; there is only a relative difference in their depth of depression and other meteorological elements. Mountain ranges have been observed to hinder their progressive motion; to cause them to break up into two or more storms; to remain stationary. But all these effects do happen where there are no mountain ranges to oppose them, even in mid-Atlantic. Yet they are of a more definite form over the oceans than over continents; and, it may be—considering the narrowness of the North Atlantic in comparison to the size of the circular depressions that sometimes exist; for the extremities of the storm may touch both continents on some occasions—that these shores may, by breaking the continuity of the wind, cause it to form two or more revolving storms, each with its axis of rotation; and, then again, there is the action of storms between themselves. They have, it appears, a few favourite places for their development—places, probably geographically adapted for their formation, taken in conjunction with other causes.

Storms, once developed, generally travel for several days in succession, from one day to twelve, or perhaps even longer. Mr. Buchan mentions a storm which passed over the United States from the 13th to 16th of March, 1859. This storm was traced from Texas on the 13th, through the United States, across the Atlantic into Europe as far as St. Petersburg, which place it reached on the morning of the 23rd, having taken eleven days to travel about 5,300

miles, travelling at the rate of 20 miles an hour. It is rare that a storm can be traced with absolute certainty that it is the same storm for a long period like ten or eleven days, owing to the interaction of the storms between each other.

In form and size they differ much; sometimes, though rarely, being nearly circular, like one on the 14th of November, 1883, which had its centre near Swinemund, and the air circulated round it over the flattest part of Europe, except Russia, where there were no mountains to destroy its form. This system, by no means a large one, was nevertheless peculiar; its erratic course was its chief feature. It advanced over Denmark on the 11th. On the 12th its centre lay near Bornholm. On the 13th it advanced to the coast of the Baltic provinces. On the 14th it had backed to the S.W., with its centre a little to the south of Swinemund. On the 15th it retraced its steps to Bornholm. On the 16th it had filled up and disappeared. Any prediction of the weather in the surrounding countries must have been almost impossible. Its extreme diameter could not have been more than 700 miles, and it was therefore a small storm. On the 19th of December, 1875, there was a large depression over the south of Greenland, having a diameter of about 4,000 miles, and extending from the Baltic, where we find the isobar of 29·9 in., to Hudson Bay; and from 35 N. lat., to, probably, the North Pole. It seems to have originated off the coasts of the United States, about the 12th or 13th, could be fairly traced until the 22nd, when it became divided into two depressions. On the 23rd and 24th three. The modifications that this storm underwent during thirteen or fourteen days were very peculiar. It will be worth while to trace it. It went forward between the 14th and 15th about 700 miles, from near Newfoundland to the south of Greenland. Between the 15th and 16th remained stationary and contracted in form on the west side.

Between the 16th and 17th progressed about 600 miles, turning to the east from its original position, having its centre now between Greenland and Iceland; also with increased depth and somewhat contracted form. Between the 17th and 18th remained stationary again. Between the 18th and 19th backed 500 miles to south of Greenland again. Between the 19th and 20th advanced the 500 miles it had backed the day before, and now lay between Greenland and Iceland again. Between the 20th and 21st remained pretty stationary, with pressure decreased to 28·10 in. Between the 21st and 22nd broke up into two separated storms, forming one for the whole revolving mass of air, which included the whole of the W. Atlantic, British Isles, and coast of N. W. Europe. One centre lay to the west of Iceland, barometer 27·75; the other east of Iceland, barometer 27·95 in. Between the 22nd and 24th it formed three depressions in a line along the 65th parallel of latitude. On the 25th the depression to the east advanced easterly 650 miles, from Finland into North Russia; the second also about 500 miles, from between Iceland and Norway to the coasts of Scandinavia; while the third and last on the parallel actually backed about 300 miles to the west, instead of following the easterly motion of the two first. On the 26th the first two depressions still advanced over Central Russia, and filled up; while the last, or westerly one, seemed to receive a reinforcement of wind and force, for it suddenly sank to 28·5 in.; and now, being separated by an arm of high pressure from the other two, took quite an independent course in a north-easterly direction. The very last of this great disturbance occurred on December 28th, when the last sign of it was to be seen in a shallow filling-up depression to the north-east of Black Sea, barometer 29·70 in.

The American International Charts show a curious and very large depression which was deve-

loped on the 19th of January, 1883, in 47 N. lat., 38 W. long. It backed for three or four days to the N.W., and on the 24th was in 67° N. lat. It then proceeded to the west, after to the south, then to west again ; and on the 29th lay off the south of Norway.* Taking another direction, it proceeded to the N.E., and disappeared to north of Norway. As this large depression probably contained many smaller systems within it, their course, if they followed the translation of the larger area, must have been very curious. In several instances, the large areas of depression back or recede contrary to the earth's rotation, and none of the laws of storms, hitherto made known to us, afford any clue to these eccentric courses. The curious retrograde path of this storm, and others like it, seems to point to some force which has the tendency of drawing two separate systems together from opposite directions ; pushing them back, as it were, from their natural course. And in many cases storms appear to have a tendency to turn back to E. or S.E., about 23° from the pole, instead of proceeding north-eastward, the usual course.

When storms exhibit such eccentric features as this, the prediction of the weather is, without any further knowledge than that we have at present, almost utterly impossible, or due more to shrewd guessing than to the application of any rules.

The mean motion of the storms which travel across Europe is about 18 miles an hour. The Storm Atlas of Mr. Mohn and Charts of Mr. Sonreil (*Annuaire Météorologique de France*, 1867) give the mean in Finland at 420 nautical miles in 24 hours ; for storms in Scandinavia 360 miles ; and Atlantic storms 480 miles. The rate at which they

* It seems probable that much of this retrograde and backing motion is only apparent and not real ; but until observations are made at less intervals than twenty-four hours, nothing positive can be stated about it. It is highly improbable that this storm on the 29th was the same that developed on the 19th.

travel on their course varies greatly in different parts of the globe, even at the same season. The wind within the area of the storm has been estimated to attain a rotatory velocity of from 70 to 100 miles an hour, and in the tropics even more. The storm which was over the North Sea on the 28th of October, 1884, travelled 700 miles in 24 hours, from the North Sea to the shores of Finland. On the 29th the force of the wind at Cronstadt reached nearly 30 mètres a second, or a little more than 65 miles an hour, and caused the waters of the Neva to rise six feet, flooding parts of the low islands on which St. Petersburg is partially situated, and was a violent storm for those regions.

We mention these few facts about storms in order to show to those, who, perhaps, have not as yet examined them, the extreme difficulty there must necessarily be in arriving at any law of prediction without some further knowledge than is yet possessed. They move onward with different degrees of progressive motion, back, recurve, remain stationary, and again proceed on their way, and that in almost every direction. But if their track could be ascertained beforehand, a great point would be gained, as then we might be prepared for a succession of them and bad weather. As to weather-forecasting, in its general aspect, apart from storm warnings, the difficulties seem almost insurmountable. Their track, it has been observed, changes from day to day; and there is more than one track observable at the same time over different parts of the earth's surface, so that a collision of storms is frequent from the tracks impinging on each other or uniting, and perhaps also owing to some mutual attraction between the storms themselves. Is it then possible to find any order amongst such conflicting conditions? It is; for the tracks obey a law, and their position from day to day may be ascertained. The writer has been able to trace the position of the storm-

tracks to the moon's declination, seemingly depending on the moon's position with regard to the earth at the time she crosses the equator, and periods of new and full moon; and there is comparatively little difficulty, once the true causes of atmospheric circulation are known, in defining, in a general manner, the regions over which they will travel; as to the greater storms, they no longer confuse by their number and variety; a principle of order can be attached to them, and their prediction rendered probable as to time and place with close approximate accuracy. Their motion, recurving, and other peculiarities, are traceable to the action of two forces; the attraction of the moon, and the rotation of the earth, which changes their path and produces other observable irregularities. All the hitherto inexplicable effects are, in the light of this theory, the most natural in the world, and receive a perfect explanation. Also the anticyclonic systems, which we said are immediately connected with the low areas—they also can be referred to the action of the same law.

With regard to these anticyclonic systems, it must be remarked that they are not separate states; but, as observed, immediately connected with the low areas; they are the states or conditions that exist between large areas of depression on their western side, and cannot be separated from any consideration of the latter. Their position depends on the place where the low pressure is at the time; and if, from the relative position of sun and moon in declination, no storms are shown to exist over any given area, there will be found the anticyclonic pressures, and they are related to the areas over which the storms are passing. Speaking generally, there are in most cases two high pressures and two low pressures over temperate zones; the former contain many smaller areas of high pressure within it; the low pressures containing also very many revolving motions, which may be called satel-

lites; and it seems the direction the greater depression takes, influences those that depend upon it, and the formation, in any particular place, of anticyclones. As to the cause of the larger areas of depression, as distinguished from the satellite ones, it *appears* they are caused by two conflicting systems of winds which the lunar theory indicates in the northern hemisphere; they seem to be the vortices produced by their meeting in certain longitudes.

Dové remarked that 'it is not impossible that both phenomena may be the result of a third phenomenon.' It is precisely this 'third phenomenon' that the lunar theory supplies. It enables us to follow out the result of the meteorological actions, as Sir J. Herschel remarked, in 'number, weight, and measure, and as exhibited in specified time and place.' It is the 'exterior power' of Captain Hoffmeyer, and one of the 'means' by which the gyratory motions are caused, and the geographical position of the anticyclones defined. It is the law which governs the barometric curve with all its variations, and every meteorological element. Any true system of the weather must include the whole world. The two systems are inter-related as much as the parts of a watch or the organs of an animal, and no motion can take place in one without a corresponding movement in the other; both claim the same origin and obey the same law. Their action seems clear: there is always the high pressure and the low pressure, and the flow of air from one to the other, but these are subjective to some other force. Their subjective relation to this other force has been acknowledged, but not shown to exist; and the system, to be complete, must include this latter. The actual daily circulation of the atmosphere is what is to be interpreted, and not the mean circulation. The usual interpretation has been based on conditions which do not exist; and, however useful and correct in its way in a general manner, could never account for condi-

tions actually observed. The internal relations of the atmospheric system are known; there are the high and low pressures, and the action between them which follows a law; the effects of moisture and its precipitation; and the consequent gyratory motion communicated to the surrounding air. By the assistance of these proximate causes, combined with the earth's rotation, statical pressure, centripetal and centrifugal force, with the general eastward translation of the atmosphere, all has been explained on assumed conditions.* The condition of the weather can be approximately estimated in the two systems, cyclonic and anticyclonic. All this has been done, and we are as far off as ever from being able to predict the weather. The cause operating in producing the departure from mean conditions has not been discovered. If the different aspects of isobaric curves are due to the same cause, which cannot be doubted; then, when this causeis known, which regulates and distributes them over different parts of the earth's surface, and tells us why they select one place in preference to another, the enigma may be considered solved; and weather —or rather storm prediction—can take its place as a true science.

If ever the weather enigma will be solved, the writer feels confident it will never be done by theorizing in the usual manner; but by taking a large and all-embracing view of actual conditions, and endeavouring to connect them with some force which could reasonably be taken to furnish some cause; and the moon's supposed influence seems the most

* We must be very cautious *how far* we accept the usual theories propounded in most works as to the circulation of the atmosphere, when it is represented as rising at the equator, descending at the tropics, flowing uniformly in middle latitudes, rising at or near the arctic circle, then flowing back to the equatorial regions, above one way, and to the poles in another; thus making, as it were, three vertically circulating systems, extending in zones round the earth. In our judgment these theories of circulation are more or less misleading and erroneous, having little foundation in actual fact, and the true theory of circulation stands little chance of being established as long as they remain unchallenged.

natural, and has also ages of testimony to support it. Surely it cannot be unphilosophical to inquire, if, after all, the influence attributed to our satellite in causing some of the anomalous movements in the atmosphere be supported by fact or not. We find that facts do support it; and that the various forces of electricity, magnetism, and also weather-changes, may probably all be traced to one common source.

After reading Ferrel's beautiful essays on the 'Movements of the Atmosphere,' where we expected to find some interpretation of real difficulties, the disappointment was great to find that we were almost where we were before in the matter. On page 8 he states:

'There are four principal forces which must be taken into account in a correct theory of the winds. The first three forces enumerated are well-known. . . . The first arises from a greater specific gravity of the atmosphere in some places than in others, on account of a difference of temperature and of the dew-point. . . . A second force arises from the tendency which the atmosphere has, when, from any cause, it has risen above the general level, to flow to places of a lower level. These two preceding forces generally produce counter-currents. Again, when from any cause a particle of air has been put in motion toward the north or south, the combination of this motion with the rotatory motion of the earth produces a third force, which causes a deflection of the motion to the east when the motion is toward the north, and a deflection toward the west when it is toward the south. . . . The fourth and last force arises from the combination of a relative east or west motion of the atmosphere with the rotatory motion of the earth. In consequence of the atmosphere's revolving on a common axis with that of the earth, each particle is impressed with a centrifugal force, which being resolved into a vertical and horizontal force, the latter causes it to assume a spheroidal figure conforming to the figure of the earth. But if the rotatory motion of any part of the atmosphere is greater than that of the surface of the earth; or, in other words, if any part of the atmosphere has a relative eastward motion, it is diminished, and this difference gives rise to a disturbing force which prevents the atmosphere being in a state of equilibrium with a figure conforming to that of the earth's surface, but causes an accumulation of the atmosphere at certain latitudes and a depression at others, and the consequent difference in the pressure of the atmosphere at these latitudes very materially influences its motions.'

Having given special attention to these four forces, particularly the fourth, we certainly cannot see how, without some further extension of it, and higher interpretation, it accounts for the anomalies of

atmospheric motion mentioned in these pages. Perfect as it is in its way, it leaves us precisely in the old position. What causes a rising of the atmosphere above the general level in certain places? It is stated by the same writer, page 13, that storms must 'begin and gradually increase in violence by the action of some constantly acting force.' This force cannot be furnished by the condensation of vapour ascending in the upward current in the middle of the hurricane, nor can it be referred to centrifugal force, *without some further explanation*; but the author does not attempt a complete solution of the problem, for he says (page 7):

'There are some uncertain data connected with the subject, such as the amount of the disturbing force, the effect of continents, friction, etc., which render a complete solution of the problem impracticable.'

According to the authorities quoted in these pages, it is acknowledged that there is a 'disturbing force' and a 'constantly acting force,' also an 'exterior force,' but where that force is to be looked for is, in most cases, left to the imagination. To disturb the atmospheric equilibrium, and cause the monthly and fortnightly periodicity which has before been spoken of, and also other movements hitherto without any explanation, there must be another agent constantly working; some exterior force causing those conditions or states of the atmospheric currents upon which gyratory motion, temperature, humidity, etc., are supposed to depend. Such are the low pressures and high pressures, and their occurrence in time and place; for cold or warm periods, and atmospheric conditions generally, depend on the distribution of pressure at the time being. That force cannot possibly be heat alone, or the consequences flowing from it; nor can it be, primarily, magnetism or electricity, which is more a consequence than a cause. There is no other force that we know of, except attraction, and this alone, up to a certain point, is sufficient to produce the pheno-

mena actually observed in their larger variations; and if it will furnish us with the power in question, we can have no hesitation in accepting it as the true one.

The action of centrifugal force has been often applied by meteorologists to explain certain phenomena observed in storms. Maury says:

'The low barometer at the centre is owing, in part, to two causes; one is the condensation of vapour with its liberated heat, as maintained by Epsy; the other is the action of a real centrifugal force, which applies to all revolving bodies.'

Strictly speaking, there is no such thing as any force or tendency in a revolving body to fly away from its centre. It is itself owing to whatever force originally sent the body in a direction between two revolving bodies, or, not straight to the attracting body. The only tendency of a body is to obey the first law of motion and go in a straight line. Revolving bodies have a centrifugal tendency; but we can imagine no motion to be produced without some cause, which is called a force, and that force which occasions the motion is called the centrifugal force of the revolving planet. The writer does not clearly see how meteorologists can speak of a centrifugal force as existing apart from another force causing the motion of the body. If, in the case of storms and the atmosphere, we imagine a constant force over the equatorial regions, then it will satisfy much of the unexplained phenomena, and particularly points out where we must look for the causes of the departure from mean conditions. Webster truly remarks:

'The wind is the result of a force, or greater pressure, at its source or origin, than at the place into which it passes, or whence it ultimately terminates. The place from which it comes, and the place to which it goes, differ in the respective weights or density of the atmosphere.'

Now the source or origin of the winds is in equatorial regions; the physical action of causes is primarily there, but for certain reasons not shown

there; for it appears, in intertropical regions, more especially at the tropics, forces are equalized and the moon's action is neutralized. But in north and south temperate zones it is otherwise. Here the result of her influence is to be sought for, and if not hitherto found, it is simply because observation has not been directed in the right way.

As we profess a knowledge of the system of the winds, as shown by the configuration of its anti-cyclonic and cyclonic systems, over a given place at a given time, it implies a knowledge of the position of every part of the system, with respect to every other part, at the same time. We accept the responsibility for temperate and arctic zones, and will undertake to indicate what system exists over any portion of the earth's surface in these two regions at any stated time.

From what has been said, it is, we think, undoubted that a theory is required in order to clear up anomalies shown to exist. If there be any science requiring the application of some reasonable hypothesis, it is meteorology; we want ideas, and not observations. A theory, provided it can be shown, in the first instance, to be capable of producing the larger phenomena shown to exist, and which contains nothing at variance with the recognised laws of nature, is absolutely necessary; for, without it no further progress will be made; and, as far as can be seen, the science is likely to remain where it is, unless these few pages push others to investigate the lunar theory in a manner very different from that of the past. Observations are ample and sufficiently extensive for the application of some reasonable thesis; and this cannot now be too often repeated, before more time, money and labour is thrown away on useless schemes, which will have no more result than many previous ones. The principal anomalies of storms and atmospheric action have been pointed out in a general manner; we might have enlarged much on

what has been stated, and pointed out other anomalies and unexplained facts, but space is limited. For the moment, the scientific question relates more to the possibility of the moon's influence; and we hope to show, that, not only is it probable; but, that it is an actual fact.

Therefore, seeing the actual state of this science, we think it may reasonably be asked, Does not the question of lunar influence open up again? We ask this question because we fail to see in what direction to look for any other cause that will satisfy the problem on all points. Nor are we without hope that some one, competent to the task, may take up the subject and investigate it further than the writer has been able to do.

We must now notice briefly the labours of those who have already investigated the subject. There is much old ground to be gone over, yet we shall try to introduce something new to our readers.

III.

Observers of Lunar Influence and their Observations.—Contradiction of Results.—Objections Considered.

It certainly seems the height of arrogance and presumption to call in question the statements of eminent astronomers on any question, or to cast even the shadow of a doubt on their observations; but we cannot withhold the conviction, that there are many very apparent reasons for refusing to give consent to their deductions when they assert that the moon has no influence on the weather. Many eminent men have examined this question. We shall mention some: Schübler, Toaldo, Flaugergues, Pilgrim, Arago, Howard. In our own times: Webster, Lieutenant Saxby, M. Henri de Parville,* M. Bouquet de la Grye, M. Rykatchew (St. Petersburg); and no doubt there are many others.

Mr. Arago submitted to investigation a series of barometrical observations with regard to the moon's phases, with the result that the effect on the barometer at the epochs of high and low atmospheric tides could not have been more than $\frac{1}{000}$ of an inch; a quantity that could certainly not have any appreciable influence on the weather. Let us see how M. Arago conducted his experiments. In Professor H. Mohn's work on Meteorology, translated into French by M. Dacaudin Labesse, it is written:

'C'est surtout depuis les recherches statistiques d'Arago que l'on répète un peu partout que la lune n'exerce aucune action sur le temps. Arago, en effet, a mis en regard les quantités de pluies tombées pendant une période de 16 ans et les phases correspondantes de la lune; il n'a relevé aucune difference bien appréciable, à celà pres qu'il semble

* 'Causeries Scientifiques,' vol. xix. 1879.

tomber un peu plus d'eau au deuxième octant. .En 1861 M. Henri de Parville reprit l'examen du travail d'Arago et, le premier il, demontra que l'illustre astronome en groupant ses chiffres ne s'était pas aperçu qu'il avait précisément masqué un des points en cause. Arago a effectivement groupé ensemble toutes les nouvelles et toutes les pleines lunes de chaque année ; or les nouvelles lunes d'été sont les pleines lunes d'hiver et réciproquement. Notre satellite se trouvant dans une position diamétralement opposée en hiver et en été pour chaque phase, les déclinaisons sont renversées. Si donc, elles ont de l'influence sur les changements de temps, il est clair, qu'en groupant ensemble toutes les nouvelles et toutes les pleines lunes, on masque complètement leurs effets distincts, s'ils existent. Arago, sans y prendre garde a ajouté ensemble autant de resultats positifs que de résultats négatifs. Résultat définitif : zero.'

Here, then, is a pretty emphatic negative given to M. Arago's deductions to begin with, and what this eminent astronomer has done in his own particular observations, others have done also.

It is, then, evident, that M. Arago's observations are not to be relied upon ; and it is chiefly since his time, and from his deductions, that the negation of the moon's influence has been asserted ; and it seems unnecessary to state, that we cannot rely on any assertions, resting for proof on other assertions, which themselves are not certain. M. Arago's observations, then, have been shown to be completely void of any scientific value as regards the supposed influence of the moon on the weather, and these observations have always been brought forward to prove that such influence does not exist.

If we take other observers, their observations are open to the same objection. Toaldo, for instance, recorded the changes of the weather with the lunar phases and the distance of the moon from the earth. He limited the changes coinciding with a new or full moon to a space from four to six days. Changes at the quarters were limited to those which occurred in a space of three days, and for those not coinciding with the phases, the changes which occurred in a single day. Now it is easy to perceive that the results of such an inquiry must have been just what Toaldo found them to be ; and if he had taken any other periods whatever, instead of the lunar phases,

and tried them by the same test, he would have arrived at the same results. Five days at the new and full moon would include a third of the entire lunar month, and thus a third of all the changes which occurred in that period were ascribed by him to lunar influence. Others noted changes without stating in what a change consisted. What difference from actual conditions constitutes a change? This, to a great extent depends on the observer's faculty for the observation of nature. I may perceive a change, my friend no variation whatever. A 'change' is somewhat a vague expression. Authorities have never decided in what a change consists, so the term may be put aside as misleading.

With regard to Pilgrim's observations, they are open to the same objections as Toaldo's. Like Toaldo, he included in his enumerations of changes corresponding to the phases, those which occurred the days before and after; this being the case, it is curious how he found a great proportion of 'changes' to occur at new moon in perigee.

Schübler's observations were directed to ascertain whether any connection existed between the lunar phases and the quantity of rain which fell in different parts of a lunar month. He also directed his inquiries to the influence of the lunar phases on the clearness of the atmosphere. From his observations it appears that the number of clear days is more frequent in the last quarter, which is the epoch at which the number of rainy days was least; also, the number of cloudy days is greatest at the second octant, which is the period at which the number of rainy days is found to be greatest. Schübler extended his inquiries to the influence of the moon's distance on rain; and he found that on examining 371 passages of the moon through the extreme limits of distance, during the seven days nearest perigee it rained 1,169 times; and during the seven days nearest apogee it rained 1,096 times. Thus, the

nearer the moon is to the earth, the greater would be the chances of rain; but this pluvial variation is so minute in its amount as to be utterly imperceptible by popular observation, and therefore inapplicable as a prognostic.

He also examined the correspondence of the wind with the lunar phases, and found that winds from the south and south-west became more and more frequent at those periods of the month at which rain was observed to increase; and that such winds were more and more rare, while winds in the contrary direction occurred oftener, towards those epochs of the month when least rain was observed to prevail. These results are in accordance, and the question respecting the mode of action by which the periods of rain are produced, would be reduced to the question of the physical action by which the moon affects the currents of the atmosphere.

M. Flaugergues made a most extensive series of observations on the fluctuations of the barometer, from 1808 to 1828, with the result that when the moon was farthest from the earth the barometer was highest—755 mil. When nearest to the earth the barometer was lowest—754 mil. As Webster remarks, this statement is directly contrary to the Greenwich observations for the year 1845; for there it is stated that when the moon was nearest the earth the barometer was highest—29·729; and when farthest from the earth the barometer was lowest—29·726. It also results from this, that if Schübler was right, and that most rain fell when the moon was nearest the earth, then, as according to the Greenwich observations, we have the highest barometer at the moon's nearest point; the greatest quantity of rain falls with a high barometer, and the least with a low one; which is quite contrary to our daily experience, and all rules for our guidance in understanding the barometer.

Mr. Howard selected the years from 1786 to 1797

for inquiry, and he found that the barometer is depressed about the tenth of an inch from either of the quarters to the full and new, and elevated in the same proportion by her return to the quarters. The curves of temperature are less striking than those of the barometer, but they indicate equally the existence of a system of variations governed by the moon's attraction as a secondary cause. Nevertheless, though Howard devoted nineteen years to the study of this question, and discussed his observations in every possible way, it appears he came to the conclusion that the moon had no influence on the weather.

With regard to the lunar cycle of nineteen years, which some persons have thought brings with it a return of similar weather; it is found that there is no correspondence whatever. Webster examined this subject and states 'the evidence is on the negative side, or exactly the reverse of what it should be.'

Let us examine the results of more modern observers. We said that those who have investigated the subject are few in number, yet some curious and important facts have been brought to light. Webster accumulated some strong evidences of monthly periodical action, which is shown by the barometrical curve, and which he regards as the indication of some general and all-pervading law; and, indeed, he who has failed to notice the peculiar manner in which the barometer curve shows, in its larger movements, a periodical action, must be a very superficial observer indeed. It is almost one of the first things that strikes us. The barometer curve rises and falls in seemingly the most irregular and capricious fashion; nevertheless in its larger development it follows a law of periodicity, which seems to point to some accumulative and culminating effect, followed by a decreasing and diminishing one; and this it would seem, must be caused by anticyclonic pres-

sures and areas of depression and some exterior force acting on the air. There is a tendency at certain periods of marked states in the atmosphere to repeat themselves; and these periods are indicated by the barometer and thermometer. Webster writes, in his 'Recurring Monthly Periods,' page 31:

'We cannot fail to perceive the broad and general fact that the same day occurs in succession for two or three months. Or that the following or approximate days of two or three months are the same, showing that there is a tendency to a periodic action in the atmosphere; and the little sections of the Analysis are the groups of approximate days of the respective months.

'These days of highest and lowest barometer I propose to regard as critical days; and their occurrence about the same day as the periodical critical day, or recurrent monthly periods of the average of thirty days, extending in their extreme range from twenty-eight to thirty-two days—altogether five days. But I am more generally disposed to limit it to a day before and a day after, contracting the extreme range to a limit of three days. . . .

'The days on which the highest and lowest barometer and thermometer occur are called the critical days of the month; there are of course two critical days to every month, both of thermometer and barometer. And these two instruments rarely accord.

'The barometrical critical days differ from the critical days of temperature, and each must be distinguished and separated accordingly; although occasionally there is an accordance between the two.

'The critical days indicate a change, and may in time lead us to judge of the coming states of the weather. They form an important feature in meteorology, and open a wide and extended field of useful inquiry.'

Webster gives several years as examples; we take five months only of 1814, to illustrate our meaning.

'Thus: 24th June, day of highest barometer is succeeded by
23rd July, day of highest barometer;
24th August, day of lowest barometer;
24th September, day of lowest barometer;
24th October, day of lowest barometer.

'Now these cannot be casual coincidences, especially as we observe a repetition on a smaller scale on many occasions.

'The consecutive series offer a very puzzling field of research—difficult in some degree, vague and hypothetical, until we are better acquainted with the facts, and have some certain and acknowledged data to depend upon.'

Again at page 158 he writes:

'But whatever day is one of the month, the order of its repetition is regular, and limited to the mean of thirty days, being the period of

its occurrence, and such a conformity to the lunar period is a very remarkable and significant fact, and still remains an unsolved problem.

'The critical days appear not to follow the order of any given day for more than three or four months, the series being interrupted, broken, and apparently capricious in this respect.'

Webster has also given the days of highest and lowest barometer and thermometer for 1845 at Greenwich, with the result that—

'The approximate coincidence within the limits of the recurring periods were seven in number, five of which occurred near the time of full moon, and two only about new moon. The thermometer displayed only four, but they were more exact.'

With regard to this year, he says:

'In this short notice of the effect of the new and full moons in producing specific states, as indicated and recorded by the faithful testimony of the instruments, we readily perceive that the full moons of January, February, March, follow on recurring days of those months. We likewise perceive how beautifully and regularly the recurring monthly periods obey the lunar influence. But in the three months which thus follow each other in succession, there is a perfect accordance between the days of the moon's and the days of the recurring monthly periods. So far all appears right, but we have a reversal of the states of the barometer. The full moon of the 23rd of January was attended by the highest barometer on the 28th. But the full moon of the next month, February the 21st, was attended by the lowest barometer on the 22nd of February, being a totally opposite state. But on the 23rd of March, at full moon, it returns again to that of January.'

Lastly, page 271, he says:

"There appears to be often a peculiar diathesis of the seasons, or some prevailing peculiarity which continues for a time; thus, one season may be particularly dry, or very wet, with paroxysms or fits of exacerbation; and in this respect there evidently seems to be a tendency to periodicity, or recurring monthly periods of the weather. There are frequently two recurring periods in the month of opposite tendencies, a kind of crisis, or critical days, peculiar to, or observable, in that diathesis. Not that the same effect always ensues, but that an evident, marked, and sensible crisis takes place, as medical men observe, or are stated to have observed, in some fevers, etc. Thus, if on the 26th of any month a violent gale or perturbation takes place, then about the 26th of the ensuing months, as long as that diathesis continues, a perturbation will be observed.'

As Webster truly says, these periods are so marked and evident for several months in succession, that it is almost impossible for any close observer of the barometer curve not to be struck

by their occurrence; yet it is not a little astonishing that no meteorologist has, since his time, taken the trouble to investigate into their cause. To the author they were so obvious that he undertook to examine them, and this examination has rendered their cause perfectly clear, and substantiated all that Webster says with regard to them.

We have given these few facts from Webster's 'Recurring Periods' to show to our readers who are interested in the question of lunar influence, or no lunar influence, that he proved most positively that there is an accordance between certain states of the barometer and the thermometer, and the periods of new and full moon. He establishes a *primâ facie* case, which merits further examination; but the author is not aware if this curious fact has ever received any further examination. But we shall return again to these recurring periods. The only cycle of the weather with which we are concerned is that of a fortnight. It is the only cycle which affords us a basis for practical work and specific inquiry. There is no occasion to seek for cycles of eight years, or nineteen years, or of sixty-one, or of any other length; the lunar month is that which is most natural, and the one which gives the most decided and positive results; and the lunar month contains two smaller cycles, two fortnights: thus a fortnight is a true cycle, and all our observations tend to corroborate this.

It appears that M. Henri de Parville has succeeded in placing on record something more positive than his predecessors; his curves show most decidedly the influence of the moon's declination on the temperature, the winds, dryness, and rain.

M. Henri de Parville's theory is founded on the effects produced by the varying declination of the moon. The moon makes a complete revolution in the heavens in twenty-seven days seven hours forty-three minutes; that is to say, she takes that

time to pass from a star to return to the same star again;—this is her periodical month. The time from new moon to new moon again is rather longer than this, in consequence of the motion of the earth in its orbit round the sun. The time between new moon and new moon again is twenty-nine days twelve hours forty-four minutes; this is the synodical month. Owing to the progress of the earth round the sun, and the moon round the earth, both are carried round the sun together; therefore the moon has to make about a twelfth part of her whole orbit in addition, which occasions the synodical month to exceed the periodical by rather more than two days.

The moon revolves round the earth in an orbit inclined at a mean angle of $23\frac{1}{2}^\circ$ to the earth's equator, and she is sometimes as much to the north of it, and as much to the south of it. When to the north, it is said the moon has northern declination, and when south of the equator, southern declination. She crosses the earth's equator twice in a month. The mean only is $23\frac{1}{2}^\circ$, but the moon may rise to 28° $36'$ north, and descend the same number of degrees to the south. She may only rise to 18° $19'$. On December the 31st, between eight and nine a.m., she reaches her extreme northern declination, which is in this month only 18° $31'$. The declination goes on increasing for nine years. When it reaches its maximum, it diminishes again for the same period. The extreme points of north and south declination may be reached by the moon, in the zenith, relatively to the earth, opposite to any part of her surface within the number of degrees she traverses, and this latter remark applies also to her passage across the equator and exact periods of new and full moon.

Understanding, then, what the moon's declination is, and by what number of degrees it varies, it would naturally seem highly probable, that if she influences the weather, this great variation would lead to a displacement of the winds and currents of the atmo-

sphere, and this is what M. Henri de Parville has actually found to be the case; for if the moon exercises any influence it would be chiefly shown through the medium of the winds. He writes, page 5, 'Causeries Scientifiques' (1879):

'Les déplacements que peut produire la lune dans l'itinéraire des courants atmosphériques doivent donc varier en amplitude chaque année. Aux plus grandes déclinaisons correspondront les plus grands déplacements de la ligne de mauvaise temps, soit vers le nord, soit vers le sud.

'Par conséquent, à ces époques, certain régions seront atteintes; certaines autres seront à l'abri. Bref, si ce raisonnement est exact, on devra retrouver pour une latitude donnée une trace évidente de l'influence des changements de déclinaison lunaire sur la sécheresse ou l'humidité annuelles.

'L'observation paraît confirmer ces vues hypothétiques. On peut se hasarder à avancer qu' aux mêmes déclinaisons correspond pour un lieu donné le même état climatérique moyen. Loi d'une extrême importance si elle se confirm.*

'Ainsi, en ce qui nous concerne, la régime des mauvais temps s'établis à notre latitude lorsque les déclinaisons lunaires passent par leur maximum et leur minimum, soit par 18° et 28°; il s'établit encore quand elles passent par 25° et 26°, et peut-être aussi, bien qu'à un moindre degré, par 21°. Voilà nos dates d'années humides. Nos dates d'années sèches correspondent aux déclinaisons intermédiaires.

'Citons des exemples à l'appui:

'L'année 1879 peut être considérée comme très humides; déclinaisons lunaires extremes, 26°.

'L'année 1875 a été pluvieuse; inondations, etc.; déclinaisons lunaires, 28°.

'L'année 1872 a été pluvieuse; inondations; déclinaison, 26°.

'Le tableau suivant accentue, au reste, ces coïncidences qui embrassent une periode de plus de soixante, dix ans et que nous pourrions prolonger plus loin encore:

Années pluvieuse.	Déclinaisons extremes.
1866	18°
1859	26°
1856	28°
1853	26°
1845	18°
1836	26°
1828	18°
1821	26°
1819	28°
1816	26°
1810	18°
1804	26°

* Il a superflu de faire remarquer qu'il ne s'agit nullement ici de la production du même temps par periode de dix-neuf ans, comme l'avait avance Toaldo; la loi est autre.

Nous avons laissé de coté, pour abréger, les années à caractère peut-être moins nettement pluvieux qui correspondent à la déclinaison 21°.

'Ainsi il ne semble pas douteux que les periodes de sécheresse et d'humidité se succèdent les unes aux autres par intervalles à très peu près constants. Lorsqu'on part du minimum de déclinaison, toujours caractérisé par de la pluie, il faut attendre six ans pour retrouver un groupe de deux années franchement humides. Après quoi, trois ans plus tard, encore une année humide.

'Exemples: 1866, 1872, 1875, 1879.

'Il semble que nous ayons maintenant six ans devant nous. La première année nettement pluvieuse viendra en 1884-1885. 1880 sera sans doubte encore peu humide, mais nous traverserons ensuite les années sèches 1881, 1883, 1884.'

Thus the rainy years occur when the moon has extreme declination, 28°, 26°, and least declination 18°; and the dry summers come between the rainy years.

If further observations confirm this theory, then it would seem impossible to assert that the moon has no influence on the weather. And, moreover, if the wind-currents and weather generally change with the moon's declination, here is to be found a reason for the different results which accompany the lunar positions. The lunar position which brings fine weather to London may bring wet weather to Edinburgh or Aberdeen, or weather of a different character again to Dublin, for the declination varies considerably daily.

On page 462 of the same work, we find the following remarks:

'En 1880, M. Bouquet de la Grye, l'eminent ingénieur hydrographe, est venu à son tour confirmer la réalité des influences lunaires dans un mémoire très remarqué; par la discussion de très nombreuses observations faites à Brest. M. de la Grye a mis hors de doute que la pression barométrique variait avec la déclinaison de la lune. Or, il suffit qu'un élément météorologique varie pour que tous les autres soient affectés; l'influence sur la pression entraine l'influence sur les vents, sur l'humidité, etc.

'La discussion de nombreuses observations du vent a montré aussi que dans nos climats la déclinaisons de la lune agit sur sa direction et sur sa force. Ainsi quand la déclinaison augment le vent du sud est plus frequent, plus stable et plus intense; et quand la déclinaison diminue c'est le vent du nord qui est influencé de la même façon.'

We are not without observers in our own country. Lieutenant Saxby has always asserted the reality of

lunar influence. He believes the causes of weather disturbances are to be found in the passage of the moon across the equator, especially when new or full and in perigee at the same time. Also when in extreme northern and southern declination. All these positions together, or singly, he regards as days of change. We believe that it is undoubtedly the moon that is the active principle in producing weather changes, and also that future observations will show, that the moon in perigee, and in or near the equator, is always followed by great atmospheric disturbance over some part of the earth's surface; and our own observations entirely corroborate this statement; but until further inquiry enables us to trace the chain of cause and effect between these positions of the moon and the weather, and is able to define, more precisely than at present, the region of such disturbance, it will be of little use for weather prevision. Nevertheless, it is well to be warned against these periods; for observations support Lieutenant Saxby's assertions that they are, in the majority of cases, dangerous periods, especially when taken in their coincidence in or near equator, and extreme declination north or south.

M. Rykatschew,* in a series of observations made to trace the atmospheric tides, has succeeded in demonstrating their existence in a forcible manner. He says:

'The observations of a year are not sufficient to determine with exactitude the little values which we search; my intention was only to direct attention to this interesting question. The result which I have obtained shows, in every case, that the tides of the atmosphere are large enough to be determined by means of the anemometer. The study of these, notwithstanding the small values shown, opens up a question of great theoretical interest; for it affords a means of finding the dependence of the atmospheric movements on a known force—that of the moon's attraction."

Mr. Newnham, in the second annual report of the

* 'Le Flux et le Reflux de l'Atmosphere d'après les Observations Anémometriques': St. Petersburg Physical Observatory.

Bournemouth Meteorological Society, found that the new moon is accompanied by a large development of south-westerly winds. These, after the fourth day, seem to have a tendency to become complicated with westerly or possibly with easterly currents. Northerly winds increase in frequency, and on the eleventh day there is a fall in their average, together with a rise in westerly winds which appears to indicate the coming of north-westerly currents. After the twelfth day northerly winds predominate, to be interrupted by a maximum of easterly winds, after which the direction again becomes northerly, with westerly currents on the increase. These become predominant on the twenty-fifth day, when an instantaneous depression of northerly currents sets in. Southerly winds commence their period on the twenty-sixth day. It is perhaps worthy of remark that Arago found that in Germany the southerly and westerly winds become more and more frequent from the new moon to the second octant.

It is difficult to ascertain whether the late Admiral Fitzroy was a lunarist or not; at any rate, he writes in his 'Weather Book':

'Every weather-wizard appeals to the moon; astro-meteorologists use unintelligible terms, and invoke electric or other unknown influences; but grave philosophers say there are not facts to prove either; on the contrary, intertropical air-tides are disproved by the barometer, and electricity is a consequence rather than a cause of atmospheric changes or movements on a large scale.

'Nevertheless, there are facts showing that the moon is at least a disturber of our atmosphere, if not a principal motor. These facts are the correspondences of extreme lunar positions with the greater disturbances of wind-currents. By such positions are meant the greatest south and north declinations (which differ 56°), and the moon's place in her orbit in a line with the sun, or between these two positions, by which the tides of the ocean are raised highest. Now there is no doubt of an overflowing or returning current above, opposite to the trade winds; and that it is strong, as well as varying periodically, cannot be denied.

'It has been lately proved that these periods are more or less lunar —occurring at weekly, fortnightly, or monthly intervals, however irregular occasionally, where interfered with or masked by local causes. These are periods of greater or less horizontal current; and this stream is impelled, it would appear, by the motion of a tropical air-tide, raised by the moon and sun; which then, as their attraction

diminishes, overflows horizontally, like the solar heat current, and augments it. While these solar and lunar attractions hold up a portion of the atmosphere above its normal level (due to gravitation towards earth's centre) no additional pressure on the barometer can be caused; and as the attractions or liftings secede or diminish, overflow horizontally must result; and these horizontal currents are proportional to the abnormal displacement.'

At any rate Admiral Fitzroy thought the lunar theory worthy of consideration, and here he considers it in a philosophical manner. He acknowledges that the moon *is* a 'disturber' of our atmosphere, if not a 'principal motor,' and, moreover, maintains that there are facts to support it. If it could only be discovered *how* it is that the moon, by some physical action, disturbs our atmosphere, and trace these disturbances to her influence, even ever so faintly, further results might be expected to flow from it. Gravitation, while it has a powerful effect on the sea, has an effect also on the air, but not in the nature of tides, properly so called. We might expect the effects to be shown more by force of wind-currents; and the force of the currents of air, amongst themselves, is sufficient to give rise to every possible gyratory motion, combined with other causes.

It will be seen, then, that the results of the old observers are somewhat contradictory and vague, and some of no value whatever. It would have been amusing, but quite unprofitable, to have given them in greater detail. Sufficient to say, they all show the absence of that careful and complete investigation which a subject, having any pretentions to be scientific, demands. Objections to lunar influence have chiefly been based on these observations, especially those made by M. Arago. But it would indeed have been curious if they had arrived at any other conclusion than that which they did. We could scarcely expect the moon's influence to be discovered by taking observations singly, either of pressure, rain, or wind, with regard to the syzygies of the moon, her quarters, or distance, without pay-

ing any attention to her position in declination, times of transit, parallax, etc. It is pretty certain that investigations continued throughout on a false basis, and neglecting causes of great importance, could not possibly yield true conclusions. The aggregate of all their observations, with the exception of Schübler's, tends to show that this supposed lunar influence certainly does not exist, and this has been repeated over and over again to the present day. It appears, nevertheless, that modern observers have been more successful, and that observation really does show some influence on the rains, and on the direction and force of the wind; but what that correspondence is, or how it is brought about, more accurate and scientific observation will probably some day inform us.

The objection that no complete cycle of the weather has ever been shown to exist has no value; for, as we have remarked, it appears that any repetition of the weather is precisely what is to be avoided.

Objections have been based on the absence of any decided instrumental indications of a positive character; for, certainly the small so-called atmospheric tide is utterly insufficient to produce the phenomena we seek to explain. But there are reasons for believing that barometrical observations will never lead to a decision on this matter. Any displacement of air, if felt at the ground-level, and due to lunar attraction, would cause an immediate inflow from surrounding regions, and thus a compensation would be effected in proportion to the displacement, to say nothing of other masking causes. The moon's influence might be supposed to be shown more decidedly by an increase of wind force and velocity; and, consequently, anemometrical observations would be of more use, in this case, than those of the barometer. We believe it has already been shown by some observers that the force of the wind is greater on lunar days; but we have not had the

means of corroborating this, nor of referring to the observations in question.

If the writer may hazard an idea which may, or may not, contain something worth considering, he would remark, that it ought not to be forgotten that there are two places on the earth where the waters of the ocean are principally affected by the sun and moon: those points where their attraction is greatest, especially when sun and moon are in conjunction, and this force is increased if the moon be in perigee. There is also a *contracted* force at all points 90° from places facing either of these luminaries. The contractive force tends to compress the waters at these places, and to raise them at those places opposite or under the two luminaries (we leave aside the fact that high water is not under the moon). The contractive force is equal to half the attractive force; and any calculated heights of the tides which do not include the effect of this force, must have half as much added to them, in order to make them correspond to the actual heights observed in mid-ocean. But in what way could these forces be supposed to affect the air? Is it not possible that their amount and effect, and also the *length of time* they act, taken in relation to the area of the earth's surface over which their effects are shown, might cause greater disturbance than is at first anticipated? It is proved beyond any doubt that the moon does exert some influence, but very slight; and effects are proportional to their causes; and, we would say, also to the length of time the cause acts in one direction. Now, it has been stated on page 71 that the influence of the moon has been shown to produce a cumulative effect, which culminates at certain periods—new and full moon, and over certain places—seemingly depending on her position with regard to the earth's surface at these times. Also that the days of extreme northern and southern declination are days of change, and especially tho days when the moon crosses the

equator. The time the moon takes to pass from one position to another is very variable; a quarter may be performed in 6 days 22 hours, or 8 days 4 hours, and frequently there is a greater difference; and so with any change from one given position to another the time is variable.

As this is the case, and presuming she has a real acting force on the air, the time she acts, in union with the sun, on a fluid resting on a solid unchangeable body having fixed dimensions, like the earth, and the energy of the agent during this time, say twelve to fourteen days, cannot be without a considerable influence. Might not even a slight effect, reinforced daily, under certain circumstances, result in producing atmospheric conditions which would develop a force at the end of certain periods, and, when at their greatest tension, cause, by a sort of reflex action, so to speak, disturbances over parts of the earth's surface?

In order to understand more fully what is here stated, it is necessary to repeat that, from about eleven to nearly fifteen days, taking the maximum and minimum, make a weather cycle. During the time the moon is passing from the equator to extreme northern or southern declination, and from this point to the equator again, the pole of the moon's declination, as it would be shown by a line on the earth's surface, and drawn daily according to the number of degrees the moon departs from the sun, performs an ellipse, it may be, over regions to the east or west of the British Isles, and may do so over any part of the region surrounding, say 23½ degrees of the terrestrial pole, at a distance equal to the actual declination from the equator.* It is round this centre that observations prove that we shall find the orbit of storms; and this pole takes half a lunar

* Each cycle is, by this means, represented by an ellipse of greater or less eccentricity, the major axis of which is nearly constant; but its eccentricity may differ very much in successive cycles.

month to perform its revolution. Now, it does not seem unphilosophical to maintain, that, as the attractive force of the moon differs considerably, by reason of her distance in each successive cycle, which is of varying length, that it probably has a considerable influence on atmospheric conditions.

Time is an element in every change that can take place; and not only applicable to mechanical action, but to chemical also; and, more or less, to every action. However, be this as it may, it is presumptuous to assert that the moon has no influence on the weather. Modern observations contradict this assertion and tend to support the opinion so long and popularly entertained. As far as we have been able to ascertain the popular opinion abroad, it seems that a change is expected with, or shortly after, new and full moon; with a very few, they are the quarters that exert an influence. Our theory indicates that the first of these periods may or may not be a period of change, and observation establishes the same; it indicates, though, that it is a period of a culminating effect of both pressure and depression over certain areas of the earth's surface. Whether the general character of the weather will change or not change over a given place, depends on the longitude of the new or full moon; this the writer has established with certainty, and the changes may occur with new or full moon, or some days before or after, and are distinctly traceable to her influence; so far this is in strict accordance with the popular opinion. When we come to the quarters of the moon, taken apart from any other coincidences, it cannot be found that they possess any influence; but, if taken in connection with extreme northern or southern declination, or the moon on equator, then they may be said to have an effect. The days of general change in the whole of the atmospheric system, are, extreme points of declination, and the days the moon crosses the equator. There are extreme conditions of atmo-

spheric pressure or depression at the times of new and full moon, but not necessarily over all parts of the globe, and these conditions are more pronounced and intensified if the moon be in either perigee or apogee.

It can be safely stated, that so far as actual facts can be brought forward that are worthy of consideration, and so far as observations have been made by the very few who have already taken the trouble to examine the subject in a philosophical spirit, the lunarists have a very strong basis to work upon, and enough to encourage them to persevere in order to attain still more decided results; while the anti-lunarists have signally failed in predicting the weather and storms, also in deducing anything likely to crush the popular belief, or to satisfy the scientific inquirer.

Have those who have asserted so dogmatically that the moon has no influence ever undertaken any observations to prove or disprove this question, and may it be considered the work of weather departments to investigate it? The evidence in favour of it is gathering strength slowly. In the name of science the question merits some attention; considering the progress observational meteorology has made of late years, the subject opens up in a new light. We think, after what has been said, it can scarcely be called 'a myth,' an 'enduring fallacy,' or 'a superstition,' as it has been stated to be by some writers. There are scientific prejudices, as there are popular prejudices: both are difficult to overcome; the latter are often based on ignorance, and, in the course of time, with the extension of education, soon disappear: the former appear more obstinate to treatment; for it seems that knowledge often confirms them, and it is generally difficult for persons to acknowledge facts that go against their own peculiar views.

IV.

Lunar Cycles, and Probability of Lunar Influence.

HITHERTO we have been engaged in showing that a theory of the weather is wanted, and that the old observers can scarcely be relied upon. We believe we have shown that there are sufficient grounds to support the popular belief. Let us see, now, what sort of observations are necessary before anything can be decided, either one way or the other, on this subject.

Our readers may say, Why appeal to the moon?—observations have proved she exerts no influence: if it had existed, it would have been brought to light long ago. Well, we have seen how observations have been made, and the results; it is pretty evident that those of M. Arago are not to be depended upon, and for this discovery we are indebted to M. Henri de Parville; and, as far as the writer has been able to ascertain, no observations have ever been made in the only manner in which they could be supposed to lead to any definite results; and, when made in that manner, they show by the most positive and conclusive evidence that it is to the moon we must look as a cause, and a very powerful one, in producing weather-changes. To establish this influence by observation, a long and complete series of observations is absolutely necessary, with regard to the moon's declination, times of transit, her position with regard to the earth at such periods as new and full, apogee and perigee. And this should be done in connection with the force, direction, and general

distribution of atmospheric pressure *as it exists actually;* also in reference to the formation of anti-cyclones and cyclonic areas of depression, and their daily displacement and changes. It has been said that, if the moon's influence is a fact, then such synoptic charts as the International American ones ought to show it. And examined in the light of this theory her influence is traceable. In every month, nay, every day, the same universal law prevails; for the high pressures, low pressures, form exactly over the places theory indicates, and can be followed for the whole of the lunar month, and traced as regards their place, and period of duration, with an astonishing accuracy; insomuch so, that the prediction of the storm track, for any period, can be defined with accuracy for months beforehand. When it is found the same effects occur, in every case, without one single exception, further proof is unnecessary. Observations then, require to be made in the manner stated, and with regard to 'time.' In the production of natural phenomena, two things always come into play, namely, the intensity of the acting force and the time during which it acts. In any really scientific observations, and comprehensive consideration of the subject, the revolution of the nodes, apsides, with regard to each other; and their position geographically, so to speak, require consideration; not that we believe it is any use whatever searching for cycles of weather; and even if it were, it is quite unnecessary; what is of more importance, is, to trace the effect shown to its cause, by some system of reasoning based on sound and philosophical principles, and to trace these effects daily. In this case, the chain of causes is long and complex, but capable of being traced; the seeming disorder is only complexity, and the law provides for it. Law has left the stamp of her presence on these conflicting elements, and nothing is left to chance in their working or in the result. As Professor Huxley

remarks: 'Chance and accident are only *aliases* of ignorance.'

For those who are not read in astronomy we shall say a few words about the moon's motions; it may cause them to perceive, that the idea of lunar influence is not so preposterous or impossible as some imagine. We stated that the cause of weather changes is the attraction of the moon on the atmosphere; thus a cause is stated from which to deduce the effects. We cannot attempt to give a demonstration of the lunar theory in these pages. To do so would require almost a volume devoted to it alone, besides innumerable figures and diagrams, both astronomical and meteorological, and a considerable preliminary knowledge of the first principles of both sciences. We leave the proof of our assertions to the forecasts or predictions at the end of our little work.

The motions of the moon are, from a variety of causes, very variable and complicated. In order to deduce the moon's true place in the heavens, as resulting from her average or mean motion, thirty or forty corrections are required, each of which represents the effect of some disturbing force, the chief of which are traceable to the varying action of the sun upon the moon. The calculation of all these niceties is one of the most laborious kind, and has occupied the attention of the most accomplished philosophers.

We stated before what is meant by the moon's motion or declination. The moon revolves round the earth in an orbit or path, inclined to the equator at a mean angle of $23\frac{1}{2}°$; so she is sometimes so much to the north of the equator, and sometimes to the south of it. When north, she is said to have northern declination, and when south, southern declination. Thus, she traverses in the space of a month 47°. But this is only the mean; she frequently rises and descends to much

more than this, and has also frequently less. In February, 1885, her extreme declination is only 18° 15′. In February, 1875, it was 28° 20′. In the short space of rather less than a month she is for about fourteen days north, and the same number of days south of the equator. She must therefore cross the equator twice in the course of a month, during her progress from one extreme position to another. The extreme northern and southern positions may occur, relatively to the earth, in the zenith to any part of its surface, over a line drawn round the earth from east to west at the extreme point reached. She may also cross the equator opposite to any part of the earth's surface along the equator; and in no two months are these extreme positions, or position with regard to the equator, precisely the same.

The moon's distance from the earth is subject to variation. She may be, when in perigee, or nearest the earth, about 221,614 miles from the earth; when in apogee, or farthest, about 252,972 miles off. Now, owing to a certain change of position, to which the moon's orbit is subject, the points which mark her greatest and least distances are subject to a gradual and regular change; so that the points in the heavens at which she reaches her greatest and least distances are different every revolution. These points traverse the whole circumference of the heavens in 8 years 10 months, and after this period of time resume their former position nearly. This cycle is that of the apsides. The attraction of bodies in virtue of their gravitation increases in the same proportion as the square of the distance diminishes, and this difference in her attractive force, especially when taken in connection with other positions of the moon, such as new or full, might be presumed to have some effect on the atmosphere, if we suppose her to produce an effect at all. This motion is irregular, being in the order of the signs, when the moon is in conjunction or opposition,

and retrograde when in quadrature. These variations of distance are produced in every revolution of the moon round the earth.

The earth moves round the sun, in the course of a year, in a path or orbit nearly circular. This annual motion, combined with the unchanging direction or *parallelism* of the earth's axis, is the cause of the seasons, which return to us periodically, but by no means equally; for we have cold summers and warm winters, and no cycle has been found for the recurrence of these extreme atmospheric conditions.

The apparent path of the sun is a great circle of the sphere, which is performed in the period of a year, and the line joining the earth and sun lies constantly in one plane, which is the plane of the ecliptic. In consequence of the annual motion of the earth round the sun, the sun appears to have a motion like that of the moon, also to the north and south of the equator; only this motion is performed in a year instead of a month. The sun also crosses the equator at the equinoxes on the 21st of March and 21st of September, and reaches his greatest declination north on the 21st of June, and declination south on the 21st of December. What the sun performs in a year the moon performs in a month.

The sun causes also a change in the declination of the calm belts, and with them the currents of the atmosphere. Maury says the belts move north from the end of May till sometime in August, when they remain stationary till winter, when they again commence to move rapidly over the ocean to the south until the end of February; then again become stationary in their southern tropic till May again. This change must affect the circulation in temperate zones. It is not, however, the attraction of the sun which produces this, but heat.

The moon's orbit is inclined to the ecliptic about 5° 9′, so she is sometimes this amount south or north of it. Where the moon's path cuts the ecliptic is

called the node or 'knot,' and eclipses can only happen when the new or full moon is in or near a node. The nodes have also a backward motion, receding 19° 21′ a year, and perform a cycle in 18 years 7 months 6 days, but this cycle of the nodes does not coincide with that of the apsides. The nodes do not recede regularly, but the angle of the moon's orbit is constantly equal. The chief feature in the motion of the moon is her range in declination. The least north polar distance of the moon is about 61° 30′, and the greatest north polar distance is about 118° 30′, a range of 57°, which is very considerable; so that we see a much greater difference between the height of the moon in the heavens at one time than at another.

The displacements, then, which the moon could produce in the atmospheric currents would be very considerable, and vary in extent every year and over a considerable area each month.

Our theory requires, however, that, supposing the moon in southern declination, there should be similar effects in the northern hemisphere, precisely as in the case of the tides; consequently the greatest range will be only 28° 30′; and observed facts agree with this theory.

It was supposed that the weather repeated itself every 19 years, when the moon returns to the same position at the same time; but no such state occurs. This cycle, which is called the Metonic cycle, is a little less than 19 years, only differing from this period of 365¼ days by a little more than an hour; so that, at the end of that time, new moon, full moon will recur on the same days of the year; but it is open to a stronger objection which renders it worthless as a weather cycle. As we remarked, the moon's distance from the earth is variable to a considerable extent, and although the cycle of 19 years corresponds with the changes of her relative position to the sun as seen from the earth, it has no correspon-

dence with the cycle of her distance, and therefore could not be expected to cause a return of similar weather; nor is there any correspondence of her position relatively to the earth. The days of new moon and full moon, etc., correspond closely this year with those of 1866; but relatively to the earth, neither in time nor distance.

If we take the 'Saros' or cycle of 18 years + 10 or 11 days (according as they include 5 or 7 leap years) and 7 hours 41 minutes, the sun, moon, and nodes will return very nearly to the same relative position which they occupied at the beginning of the cycle, and also their distance will be the same, or very nearly so. But this phenomenon will not return on the same days; moreover, on account of the 7h. 41m. difference, could not produce the same effect on the weather over a given place. Eclipses return in the same order and nearly of the same magnitude in this cycle, but the difference of 7h. 41m. causes them to be visible at different places. The reader can verify this cycle for himself by reference to the Nautical Almanac for 1867, and comparing it with the one for the present year. On March the 16th, 1885, there is a recurrence of the annular eclipse which took place on March the 5th and 6th, 1867, and that after the lapse of 18 years + 10 days 7 hours and a few minutes. By observing the lines giving the graphic delineation of the eclipse, it will be perceived that it is similar, covering the same extent of surface and of the same form; but that in 1885 it is removed about 7h. 41m. to the west of its original place, so becomes visible to other nations. The cause of this is obvious; for if we find on a globe the position of the sun and moon, we shall see they were in a line with the earth in 1867, in about 30° or 35° E. long., declination 5° S. In 1885, they were in a line with the earth in about 80° W. long., declination a little less than 1° S., and in both cases about the same distance, for the moon

was in perigee 7 days after the time of new moon. The eclipse of August the 28th, 1867, is reproduced on September the 8th, 1885, under similar circumstances, and also removed 7h. 41m. to the west. So far, then, as the vicissitudes of the weather can be supposed to be influenced by this cause, it would be translated 115° from its original place after the lapse of the cycle. It might be expected that an approximate recurrence might be shown of larger disturbances, only removed by such a number of degrees in longitude, and about 5° in latitude, but very different geographical conditions, and other circumstances, would prevent such recurrences; except in possibly a vague manner; for it must always be remembered that the actual weather over any given locality, depends on such delicately balanced forces in their relation to each other—such as tension, temperature, moisture, electrical condition, etc.—that the original forces acting in producing the states these conditions depend upon, would have to occur with extraordinary exactitude. If, in any period of time, the different cycles of the moon returned in the same position relative to each other, and had the same position with regard to the earth, we might expect to have a recurrence of similar weather. The lunar theory requires that the cycles of nodes, apsides, new and full moon, should, so to speak, pull together; and that they should do this in the same relative position with regard to the same points on the earth's surface. If we search for a cycle in which the said conditions will be satisfied, and sun and moon will have the same right ascension, declination and distance; then it will be probably a period of 32,436 years less one hour. Nor does the prediction of storms require any such cycle; the great areas of depression can be perfectly well predicted without it; and the necessary deductions, as to what weather will be experienced at any given time over any part of the earth, can be drawn; and the changes in those condi-

tions followed in time and place, from the knowledge of the position of the sun and moon in the heavens, and relatively to the earth at certain times; also the position of the moon when she crosses the equator.

A lunar month is composed of 29 days 12h. 44m.; the moon takes this time in going from new moon to new moon again. Each succeeding new moon happens, with respect to the earth, opposite to very different places, varying each revolution in right ascension and declination; and it is the part to which she is opposite at the time of new or full, also her transit of the equator, that determines the weather of the entire globe for the fortnight; and each succeeding fortnight, as new positions are taken up; so, corresponding changes occur in the distribution of the weather, the tracks of storms, and their high pressures.

There is a cycle of 61 years, and after this lapse of time the changes of the moon will take place on the same days and about the same time, only the order is reversed; thus, in 1823, February the 10th was the day of new moon, 15h. 5m. astronomical time; but on February the 10th, 1884, we find full moon at 16h. 47m. The full moon of 1823 took place on the 24th, 17h. 6m., but in 1884, we have new moon on the 26th, 6h. 35m., and if we refer to the dates and hours of the changes, there is an approximate correspondence in time and place; but this will not bring us much nearer to any weather cycle, except perhaps a very vague and broken one; the declination differs, often considerably, and the parts of the earth to which the reversed phenomena are opposite, as well as the distance of the moon.

In former considerations of weather cycles depending on the moon, no account has been taken of the difference between the cycles themselves, and the parts of the earth to which the moon in extreme positions was opposite. Observers have left these important points on one side; before we can deduce any true

weather system from them, it is absolutely necessary to apply a correction for the difference between the place to which the new moon is opposite, and the given place whose weather is required to be known. It will naturally be asked: How can a few hours' difference in these definite positions cause an effect on the motions of the atmosphere? Why this should be so seems capable of explanation on lunar and *solar* action combined.

The moon's influence is certainly not shown in the form of tides, or anything corresponding to them; it is shown by causing a collection of air at two parts of the earth's surface, and a diminution at two others, precisely as shown in the monthly mean charts. The lowest area of pressure for the winter months is shown to be over or near Iceland, and over the Aleoutian Isles in the Pacific; but these depressions can and do occur, in a lesser degree, over any part of the earth's surface in temperate zones. It is not astonishing that the mean pressure should exist where it does; natural laws explain this perfectly; for on account of the moisture of the air over the oceans being in excess, and precipitation greater when this moisture is condensed by colder regions, a vacuum is caused into which the air turns. These great areas of depression, which are often composed of smaller areas within them, take up their position according to the relative position of sun, moon, and earth, and they change their place with the moon's declination. In the middle of the winter months the high pressures sometimes cover the entire Atlantic, and last a long time. In February, 1875, a high pressure covered Iceland and the Atlantic generally, from the 16th to beyond the 28th, culminating to 30·512 in. on the 23rd. This is just the opposite of what should have taken place on the usual interpretation of atmospheric circulation. Low pressures occur over Central Russia and Siberia during winter months, where the high pressures should be. These

and other irregularities are perfectly explained by the lunar theory, and no other can afford any interpretation of them. As we said, these cyclonic and anticyclonic systems take up their position according to the position of sun and moon, and are distinctly traceable over the earth's surface, throughout the period of a lunar fortnight, to the moon's declination, and that in any period of the year we like to take, and under any geographical circumstances, we may conclude that, whatever may be the cause, and by whatever action produced, the periods of new and full moon do produce an effect.

Sir J. Herschel remarks, in his 'Meteorology,' page 69 :

'The atmosphere, like the ocean, has its waves, which are rendered sensible by the increase of barometric pressure as the crest or trough of the wave passes over the place of observation. They are, however, on a much vaster scale than those of the sea, as might be expected from the greater mobility of the medium and the extent of surface over which their exciting causes act simultaneously. But they are distinguished from the latter by features of a peculiar kind, which depend on two causes, viz.: 1st, the varying density of the air, from the earth upwards ; and, 2nd, the fact that the disturbances in which they originate are not (as in the case of sea-waves) merely superficial, but extend through the whole depth of the atmosphere, and are more powerful at the ground level.'

After, however, we are told that the *gravitation* tide depending on the united attraction of the sun and moon would only cause a difference in the level of the aerial strata of about six feet, and its effect on the barometer would therefore only amount to about 1·130th of an inch. Now, if this latter statement be true, the effect of moon's attraction could scarcely produce any material effect on the air ; and, in fact, there is nothing to support the *tidal* theory ; at least, the barometer shows no such effect that corresponds to tides in the ocean, yet it is just possible, from various reasons, barometrical indications may be masked, and the moon's effect neutralized ; anemometrical observations show most distinctly an effect due to the moon ; and from the nature of the force,

and the medium, it might naturally be expected that the moon's influence would be shown by increase and decrease of wind force more than by tides properly so called. From the nature of the moon's cycles, and the absence of that unison necessary to produce similar effects, the cause differs monthly and yearly through an immense number of years, as regards the absolute time, or the absolute place of its occurrence, so likewise will the effects produced; and although the cycle of the moon's nodes, apsides, etc., does not coincide exactly in the heavens relatively to the same part of the earth in any number of years, in order to cause a return of similar atmospheric conditions over the same place; yet each lunar fortnight sees a recurrence of effects having a certain resemblance to those of a preceding month; changed only in their latitude and longitude, and modified by the surfaces over which they pass. There is no occasion to search for any longer cycle than that of a lunar fortnight; it affords all that is necessary for weather prediction, and its results are certain in their recurrence.

We have already noticed that Webster proved the fact of there being recurring periods of atmospheric action for two or three months, and then the series broke off and another took its place, or reverse extreme conditions showed themselves. So obvious are these recurring periods for some months in succession, that it is almost impossible to deny that the moon has the presiding power; but Webster did not succeed in tracing the cause of the reverse states, nor their suddenly breaking off. The lunar theory absolutely requires that this should be the case; nor can there be any return for more than three or four months in succession of similar or reverse conditions; sometimes two months may show much resemblance, even three or four less so; sometimes no resemblance at all between two months; all this depends on the position taken up by sun and moon at new and full

relatively to the earth. Thus the extreme conditions vary in latitude and longitude each month; probably in the second, third, or fourth month, as the case may be, bringing the high pressure where the low pressure was before, or nearly over the same place, but never exactly. Some action of this sort seems to be shown by synoptic charts for the whole of the northern hemisphere when taken in conjunction with the lunar positions. The recurring periods are no longer a mystery, nor the reverse conditions; and the larger phenomena, exhibited by the charts, seem to point, very decidedly, to the moon as the preceding influence. The satellite depressions still form a difficulty, for their prediction is less certain; and as there seem to be also secondary satellite depressions, and often deep and dangerous, their prediction is of great importance; but no doubt this difficulty will eventually be overcome. As the law governing the larger ones is known, the smaller ones will undoubtedly be found to take their place in some subordinate system depending on the larger areas.

It is not a little astonishing that astronomers like Arago and others—who must have known all about the lunar cycles and their relation to the earth; also the laws of gravitation and mechanics; of forces and their action—should have set about making observations to discover the supposed lunar influence in the way they did. That they should have arrived at a negative, or only very vague indication of such influence, is only what is to be expected. As if it were possible to expect the new moon to bring in each successive month any definite change on the same day and place! The place to which the new moon is opposite is continually changing, and the weather too. The general character of the weather is continual change: change is the law and rule, and it corresponds to the moon's cycles, which are always changing also. 'Like causes produce like effects,' but

in each succeeding month or year the action of causes is not alike; and the smallest variation produces a very great change in the weather conditions over any given place, and in the readings of barometer and thermometer. According to M. Henri de Parville, Arago conducted his observations so as to completely mask the influence he sought for, and it is not astonishing he arrived at the conclusion that the moon's influence is an error. Although Arago did not succeed in establishing anything positive on the subject, he did not altogether deny that it might not exist; for he defended the popular idea within certain limits. Considering also that the air and atmospheric disturbances have an eastward translation over the temperate zones, all sorts and conditions of weather must pass during a month over the regions traversed, and never twice alike over the same spot; thus, observers would naturally fail to find any weather corresponding with lunar phases and positions; but this is no argument against the moon's influence. The connection of barometrical indications with the weather is sufficiently obvious; but the connection of both with some other external cause, such as the moon's attraction, has baffled all observers up to the present time. The path of the moon does not return unto itself, but is a curve of a very intricate kind, and undergoing perpetual change. There is no unity on the recurrence of the cycles themselves in any period of time, that will afford us a practical cycle as a precedent to judge the coming weather; consequently, all search for a connection between the weather and our satellite, in the manner observations were conducted, could only result in obtaining no definite proof either one way or the other. The system of means and averages could never decide this question; and as regards lunar influence they only mask it; and it is difficult to see in what way all these observations will ever become useful to the science. We obtain the totality of results imparted to the atmo-

sphere for the time the means are calculated; but all this, without any connection with the actual cause, which has its laws, acting in time and place, is perfectly useless. But if further observations continue to substantiate the moon's power over the wind currents; and, that we may regard her as the external agent actively employed in producing a displacement from one configuration of isobars to another; each having different degrees of energy, as shown by mean wind force and greater or less atmospheric disturbances; means and averages, made in a certain manner, with regard to certain periods, such as from transit to transit of the moon, or during the period of a fortnight, may lead us eventually to be able to calculate the amount of work performed during such time by the moon, and also to the estimate of the force exerted in producing such work and change.

When we reflect on the arrangement of the lunar cycles, we find that they are the very best that could have possibly been invented to produce the effects they do produce: to give us an endless variety of seasons, with no two alike—cold summers and warm winters, and *vice versâ*—and to distribute to each part of the earth's surface in succession the weather necessary for the health and well-being of the animal and vegetable kingdom. They prevent the winters from being too cold and the summers from being too hot. The distribution of the cycles, unequally, is a providential arrangement, and points to some ultimate end foreseen by the great Creator from the first commencement of creation. They have been cycling through ages of time, and bringing with them, and dispensing the winds and storms to all nations of the earth, in strict accordance with law, and probably never bringing precisely the same or similar weather along with them; for in the course of the time probably required to complete the cycle, changes from other astronomical causes may have come into operation, tending to prevent an exact recurrence of

similar conditions. And very serious consequences affecting geological changes, as far as they depend on these external circumstances, flow from this theory of lunar influence, once it is established. The winds and storms have played their part in the progressive development of our planet, and must have exerted much influence in modifying its surface and external structure, as well as the organisms to which the great mother earth has given life.

If the sum of the causes had pulled together with respect to the earth, there would probably have been a periodical return of precisely the same weather to each quarter of the globe; no beneficial variations; and the seasons would have returned to us with the same wearying monotony; the weather enigma would have never existed, and eclipses would have occurred of the same magnitude every lunation.

Indeed, this department of terrestrial phenomena does not resemble cosmical in the simplicity of its effects. The motions of the sun and moon were known from very early ages. The Chaldeans invented a cycle for eclipses, and these events were foretold with some degree of precision. From the earliest periods men must have been deeply interested in the motions of the sun and moon, the stars and planets; while comets were regarded as harbingers of events the most terrible. Nevertheless, these motions, from their frequent repetition, were reduced to some order, and that order reduced to a law. Mankind must also have been struck with the great contrast presented between cosmical and terrestrial phenomena—the former continuing on its course in a steady and comparatively uniform manner; the latter so variable and capricious.

If we are to regard meteorology as purely a terrestrial phenomenon, then, indeed, it would seem hopeless ever to think of arriving at any laws by which to predict the weather, or even storms; for most of its phenomena are the results of causes, many of which

are very imperfectly understood; always changing in intensity, place, and time, and mixed up with the earth's rotation as well as the changes produced by day and night. The working of the most trifling elements leads to results the most terrific and alarming. What a beautiful meteorological phenomenon dew is, and by what subtle and invisible processes it is brought about! Dew is the deposition of the invisible vapour held in the air in the form of water. If the temperature of a given place be higher than the dew-point, water will evaporate and rise into the air; but if the mass of air be gradually cooled, it will descend to a degree of temperature at which it will be saturated by the quantity of vapour then mixed with it. This temperature is that of the dew-point. If the temperature be lowered, some portion of its vapour will be deposited in little round pearly drops on the objects with which the air is in contact. It has a preference for certain substances, such as grass, paper, wool, furs; and if there be much wind, it will not be deposited at all. The process of precipitation is immediately suspended if only a considerable cloud passes over the place of observation. When it is deposited, heat is given out; the temperature rises and oscillates about the temperature of the dew-point. It is charged with electricity, and this increases as the dew-drops unite, and thus other invisible and mysterious forces are called into action. The air becomes electrified, and the coalition of these drops as rain produces, in the higher regions, not only a vacuum to which surrounding air rushes from all sides, but we frequently become surrounded with startling and even terrible effects; the lightnings go forth and the thunder rolls in the canopy of clouds. How can these things be predicted, if the air does not contain in itself all the causes of its own phenomena, which it certainly does not? All the observations ever made of the meteorological elements have not brought us one iota nearer to the final end of the

science—prediction of weather. It is evident that there must be some remoter and more general cause influencing and guiding the atmospheric currents from without, and upon which their invisible and subtle elements to a great extent depend. So very much in this beautiful realm of nature is regulated by causes so exquisitely and finely balanced, that their prediction seems to be beyond the reach of human calculation.

Our readers may smile if we state that the falling of a drop of dew is primarily owing to a cosmical cause; and yet, if the moon influences the weather, this most insignificant of phenomena is equally caused by the moon as the cyclone or tornado; for a cause, if it be a true one, must propagate itself into the most remote effects of that cause. If our little dew-drop could speak, it could assert its reason for being where it is, why it is there, and its right to be there. It cannot fall to the ground without partaking in the universal law that governs the motions of the universe; and as to its cause, we cannot expect it to be otherwise than due, through an infinitely long train of causation, to that which is the first in producing all weather changes, and which governs, leads, and directs them.

It must be admitted that we have not strictly adhered to the wording of our title-page, which states this work to be a reconsideration of the probability of lunar influence, based on such facts as have been already ascertained. But considering that a great number of years have been spent in observations, made at considerable cost of time and trouble, and undertaken for the express purpose of eliciting, if possible, something more positive than hitherto presented in support of lunar influence, we considered our own results merited some attention.

Had we any intention of showing, by reference to actual fact, some of the curious results arrived at,

and of demonstrating the manner in which the moon might, probably, by her attraction exert an influence on the atmosphere, supposing it is really sufficient as a cause; in the first case, we should require very many diagrams, and synoptic charts for at least a fortnight; and in the second, it appears the difficulty would consist in the solution of a very difficult mechanical problem, which mathematicians might express in accurate formulæ. But before any attempt of this latter sort can be thought of, it is obviously necessary to establish some facts that point out in a definite manner that it is really to the moon we must look for a solution of the weather enigma. If we can establish this, then further opinions may be expressed as to the means by which the different forces act so as to produce the results actually observed, and an attempt might be made at some sort of demonstration.

We have only touched on several important questions which appeared to point, for their final settlement, to some exterior power, some cosmical cause of a nature quite unlike the sun's heat; and much more might have been said, and our remarks might have received further development. What has been stated is sufficient to show that those very principles upon which the science of meteorology depends, if it is worthy to be called a science, are the ones for which no search has ever been made; and those conditions of the atmosphere upon which storms and disturbances might be supposed to depend for their prediction, are precisely those of which no explanation has ever been offered; also, that it is scarcely more observatories that are wanted; or rather it is scarcely more stations that are required, but more frequent observations at intervals of four or six hours, and the compiling of means and averages with reference to some theory that might furnish us with an explanation of the manner in which the science works. It is evident that in this

science, as in all labour, whether scientific or otherwise, work without any organizing and designing mind is less productive of results than it might be. It is the prescience of thought which rules, arranges, combines, and develops, and works to arrive at a certain end: to see that end is wisdom; to reach it is our duty; and to stop there is force. This fact is recognised on the appointment of a commander or general to an army, but not always in other things.

But it is easy to find fault and point out defects and anomalies; it certainly would be the better way to clear them up and give some explanation of them. Have we, then, anything to offer which may eventually lead to this desired end?

To sum up, then, what has been stated in rather a fragmentary manner with regard to our own theory, which was briefly and generally stated in our preface, and frequently spoken of throughout these pages, we shall remark, that this extraordinary fact, which the writer has been the first to point out, requires some explanation from the scientific meteorologist or the astronomer, and it would appear more the work of the latter.

Observation has put it beyond doubt that the primary area of storm depression, atmospheric disturbance with low barometer, minimum, or whatever it may be called, circulates, not round the terrestrial pole, but round the pole of the moon's declination as it would appear if projected on the earth's surface, and when represented by a line indicating the departure of the moon from the sun every twenty-four hours. And that this area of depression revolves round such point or line at a distance from it equal to the moon's declination from the equator, whatever that may be.

There appear to be, also, two other systems of circulation containing storms which circulate round, and with a tendency towards the centre of the first; and these are also situated at a distance from the

first equal to the moon's declination. When the moon is in extreme northern or southern declination, supposing her declination to be 18°, the eastern and western extremities of these two systems meet the extremities of another such system in the opposite half of the hemisphere about 80° east and west of the centre of rotation of the whole system, and in the middle of temperate zones. It is necessary to remark, however, that these secondary systems are not always at a distance from the first equal to the moon's extreme declination; they appear to have a motion round and towards the first, and the storms they contain obey the declination of the moon in this respect; so that when the moon approaches the equator, the two secondary systems appear to unite at the terrestrial pole with the first. Consequently, the storms they contain pass off to the north-east and disappear. As soon as the moon proceeds to her southern or northern declination again, the systems separate and the storms reappear, but over another part of the earth's surface; depending, seemingly, on the region traversed by the pole of the moon's declination.

But observation shows that this alone is not sufficient to satisfy the problem. Theory requires, and facts seem to prove, that there is precisely another such system, or series of systems, on nearly opposite sides of the same hemisphere; but how caused is beyond any explanation whatever, unless they be due to magnetism. The *edges* of these two systems meet in the temperate zones in varying degrees of latitude, and a large area of barometrical depression is found to exist between the two systems, and this consists, generally, of three partially separated depressions.

We said that when the moon approaches the equator, the secondary systems which depend on the first seem to unite with it, and the storms tend to disappear to the north or north-east; but no sooner does this take place, than about a day before

other systems with storms appear to have been developed to the south of the first, and these, when the moon is at her points of extreme declination, are not traceable, but come into existence in the south of temperate zones as the moon approaches the equator; these travel for some days over the earth's surface, and in their turn finally disappear. For some reason or another the storms that are found in the southern systems do not appear to obey the same law with regard to their attraction and repulsion from the centre of rotation as those which belong to the first systems, and their prediction is more difficult than those of the latter.

On reference to a large synoptic map, such an order of circulation as here described will very rarely be found; but there is evidently an order of circulation of this nature which lasts for a time—about a fortnight—over a certain part of the earth's surface.

If these systems be traced on a polar projection of the northern hemisphere, we get a series of overlapping circles, the centres of which are distant from each other by a distance equal to the moon's extreme declination from the equator, and we get in appearance precisely such a series of systems as iron filings show when placed on a bar-magnet; whether this relation is merely one of accident, so to speak, or some coincidence of law, is a curious question.

An immense number of observations have proved this great fact—that the whole system of atmospheric circulation is in the form of a great number of gyratory motions, primarily caused by the moon's influence, yet intimately connected with other forces which come into play; that currents flowing regularly from the equator to the pole and back again do not exist. The first of these rotatory systems contains the great central area of barometrical minimum; this itself has a progressive motion from and to the terrestrial pole, and it leads in its train all the

other rotatory systems or satellite depressions which revolve round, and with a tendency to revolve into, it. The whole would be clearly traceable but for the earth's rotation and terrestrial masking causes. Thus, if this theory be true, it appears that storms and all gyratory motions of the air are analogous to the planetary system, and perhaps governed by the same laws, though subject to the disturbing influences of the revolving body on which they themselves revolve.

Now the author is perfectly aware that this description is very superficial, and inadequate to give a full explanation of the phenomena in question. It is quite impossible, without great lengthiness, to enter into the consequences and details of this theory: the preceding remarks will suffice to give a general idea of it, and more cannot be attempted within the scope of these few pages. It is given to show to our readers what may turn out to be the actual circulation of the atmosphere, but it certainly may be in some points incorrect. It is by no means entirely theoretical. It is a curious fact that storms do follow each other in these systems at well-defined intervals over the earth's surface, and in some such order of circulation; also with greater precision as we advance to the north; while to the south they have a tendency to disappear, and do not always show themselves when expected. It seems that all the forces concerned in the motion of the atmosphere are balanced at about 28° north and south, and at these regions there is no motion of the air either way.

The following forecasts are sufficiently well defined as to both time and place, and will in the majority of cases occur on or between the days mentioned, and within 5° of the places indicated; in many cases precisely over those places. Certain periods will be found to be very exact, as well as the depressions that occur within them; especially those where the depressions are numbered. These periods

in the second column mark the passage of the central areas of barometrical depression, upon which the others, secondary or satellite depressions, depend; they are generally stormy periods, of varying intensity, for the districts around them, and two of the depressions are generally deep and severe according to the season; the third is more frequently shallow, forming, or sometimes filling up.

It has been observed that the central area of depression is very frequently composed of three separate, or partially separated, gyratory motions; extending, not in a line, but in a triangular form; with two in the north and one in the south, and these three form the central area of low barometer. Each of these three depressions is frequently traceable, though not always, on the daily weather maps; a tendency only is sometimes found; at other times, one of these three depressions may pass over the British area between the hours of observation and so be lost sight of.

There are depressions marked 'uncertain,' and these generally occur when the moon is in or near the equator; and at this time, experience has shown, it is extremely difficult to trace depressions; especially when they become mixed with those due to previous lunar positions, such as new or full moon. However, when these depressions do occur, they will be found to be, generally, deep and severe for the season, but the exactitude with regard to time and place that will be shown by the numbered ones, wherever they occur, is not claimed for them.

The depressions of which the central area is composed are not always deep, unless they happen to pass the British Isles at the time of new or full moon, and also when she is in or near perigee or apogee. Usually they cover a more extensive area of the earth's surface, and this is especially the case when they unite in forming one large depression. The satellite depressions which accompany the

central area at its circumference, are frequently more violent and dangerous than those which form the central area itself. Those storms and gales which occur when the moon is over or near equator, are, observations have proved beyond doubt, more dangerous and violent than any others; and this is increased when she is in or near perigee at the same time, and still more so when new or full moon. But as these violent disturbances cannot occur over all the globe at once, it is necessary to define the place of their occurrence, and this is what is here attempted. At these periods, extreme atmospheric conditions do occur, both of pressure and of depression; some places are necessarily situated in the mean regions of these extreme conditions, and therefore those places, at these times, experience no exceptional disturbance.

It is requested that if a *tendency* be shown for a depression to form, as well as a subsidiary one, it may be counted as a depression. A tendency to form is easily recognisable by those accustomed to the study of the isobaric curves. Nothing is said about the weather accompanying the depressions or high pressures; the object here is simply, first, to show if areas of low pressure can be predicted or not; yet an idea of the probable condition of the weather can be fairly obtained; for the leading features of cyclonic and anticyclonic conditions are well known to all who study the barometer and the weather.

It is impossible to state, to a day, when the periods will begin or finish; nevertheless, it will be found that they are divided with approximate accuracy by the division lines in the first column. Depressions may occur during anticyclonic periods, but they are generally of a relative character.*

The British area is sufficiently extensive to show

* If the periods marked 'anticyclonic' are not strictly anticyclonic, they will be found to be periods of relatively higher barometer.

all depressions except those which pass Bodo, 67° 20′ N., 14° 30,[1] E.* The depressions have not been traced after passing the British Isles, except in a few cases, where their path seemed to be tolerably well defined and free from intermixture with depressions of other systems of atmospheric circulation.

Considering the great and almost insurmountable difficulties in tracing each depression through a long chain of cause and effect, if, in this first attempt at anything of the kind, an approximation is arrived at, and the depressions occur when and where stated, it will put this long undecided question of lunar influence beyond doubt, and will, perhaps, cause the question to be discussed on a scientific basis, which has never yet been done, by those having greater resources and abilities.†

* The French newspaper *Le Temps* gives the most comprehensive weather map, extending from Africa to the N. of Norway, and in the East to St. Petersburg.

† The writer begs no indulgence from his readers except for the month of April, which has proved difficult of analysis: the months following will be found more correct. Fair and impartial comparison of the forecasts with the depressions, as shown by the isobaric curves of equal pressure on the weather maps, will, he thinks, support the theory advocated in these pages.

PREDICTION OF STORMS, OR AREAS OF DEPRESSION, FOR APRIL, MAY, AND JUNE.

DATE,		APRIL. BRITISH ISLES.	OUTSIDE BRITISH ISLES.
1			Depressions N. Cape, 1st, No. 1.
2	ANTICYCLONIC PERIOD.	Depression W. of Ireland, 2nd or 3rd; uncertain.	Depression S. Spain, 2nd or 3rd.
3		Storm area approaches B. Isles.	Depression, Bodo, 3rd, to White Sea, No. 2.
4	STORMY PERIOD AFFECTING ALL ENGLAND.	Depression No. 1, Shetland, 4th.	Depressions Spain to Mediterranean; 4th to 6th; uncertain.
5		Depression No. 2, British Isles, 5th.	
6		Depression No. 3, Shetland, 5th or 6th.	Depression near Denmark, 6th or 7th, uncertain.
7		Depressions S. coasts between 6th and 7th.	Depression St. Petersburg; 7th or 8th.
8	UNSETTLED IN S.; PROBABLY ANTICYCLONIC IN N. & N.E.	Depression Ireland to Shetland, 8th or 9th; uncertain.	
9		Depression between 9th and 11th across south of England and Scotland N.W. coasts.	Storm track crosses Norway, Finland to N. Russia, 7th to 9th.
10			Depression Christiansund, 9th; Bodo, 10th, No. 3.
11			
12		Depression N. Scotland or N. Sea, 12th or 13th.	
13	ANTICYCLONIC PERIOD.	Anticyclonic Period over British Isles to 16th; Europe and Scandinavia to 17th or 19th; may last to 19th in N.	
14			Stormy United States, 14th, 15th, 16th.
15			
16			Depression N. Cape, 16th.
17		*Depression S.W. of Ireland, 17th; uncertain.	Depression, Bodo, 16th or 17th, No. 4.
18		Depression extreme S.W. coasts, 17th to 19th, to Bay of Biscay.	Stormy in Atlantic N. of 50°, 18th, 19th, 20th.
19			Depression Christiansund, 18th or 19th, No. 5.
20	STORMY PERIOD TO 23RD.	Depression No. 1 N.W. coasts, between Faroe Isles and Scotland, 20th.	Depressions S. Europe, Spain to N. Italy or Austria, 20th to 22nd.
21			
22		Depression No. 2 Stornoway; 21st to N. Scandinavia; probably deep.	
23		Depression No. 3 Faroe Isles, 22nd.	
24	UNSETTLED.	Depressions N.W. coasts, 24th, 25th; uncertain.	Probably low over Spain or S. of France, 24th to 26th.
25			
26	ANTICYCLONIC PERIOD.	Anticyclonic generally over British Isles to 4th or 5th of May after the 27th.	
27		Depression N.E. coasts on 27th; uncertain.	
28			Depressions extreme N. of Scandinavia to N. Russia.
29			
30			Depression 3° N. of Faroe Isles on 30th.

Stormy generally in Atlantic from 1st to 4th, particularly north of 55°.
The stormy periods when the central area will pass British Isles are, from the 4th to 7th; and 19th to 22nd or 23rd; N. Scotch coasts.

* These depressions may cross centre of British Isles between 19th and 22nd.

MAY.

Date.		British Isles.	Outside British Isles.
1	ANTICYCLONIC PERIOD.		Depression Christiansund, 1st, No. 1, across Scandinavia to Russia.
2		Anticyclonic Period to 4th or 5th.	Depression N. of Faroe Isles, 3rd.
3			Depressions N. of Spain between
4		Depression S. coasts, 4th; uncertain.	2nd and 4th.
5	STORMY PERIOD IN N.W.	Depression N. of Scotland, Stornoway, 4th or 5th.	Depressions in Atlantic, N. of 50°, 3rd, 4th, 5th.
6			Depression N.W. of Faroe Isles, 5th or 6th, No. 2.
7		Depression between 6th and 8th, S.W. coasts.	Depression little to N. of Faroe Isles, 7th or 8th.
8		Depression N.W. coasts between 7th and 9th.	
9		Depression Shetland between 8th and 9th.	
10	ANTICYCLONIC PERIOD.	Anticyclonic Period; probably highest in centre and N. from 10th to 13th.	Depression S. of Bay of Biscay, 10th or 11th.
11			High pressure over Iceland and to
12		Depression N.W. coasts of N. Scotland to N. Sea, 13th; uncertain.	N., 9th, 10th. High pressure over Scandinavia.
13			Denmark, Baltic, Finland and N.
14			of Russia, 11th to 14th. N. Cape relatively low.
15		*Depression probably centre of British Isles; 15th, Stornoway, 16th, No. 1, deep.	Depression N. of Christiansund, 15th or 16th; deep to Finland, No. 3. Very stormy Atlantic, 14th to 16th. Storm track crosses N.
16	STORMY PERIOD.		Atlantic. Depressions N. of
17		Depression No. 2; centre of British Isles.	Spain to S. Europe, 17th, 18th.
18		No. 3, N. coasts; Shetland, 17th or 18th to N. Sea.	
19		Depression S.W. coasts, 19th; uncertain.	
20		Very squally, 16th, 17th, 18th.	Depression Faroe Isles, 20th, No. 4.
21	UNSETTLED; PROBABLY ONLY IN S.W. AND S.	Depression; probably stationary outside W. coasts, 21st to 23rd; uncertain.	Low pressure Mediterranean, 21st, 22nd.
22			
23		Depression S. of England, 23rd to 24th to N. France.	Depression Christiansund, 23rd or 24th; uncertain.
24		Probably Anticyclonic in N. and N.E., 24th, 25th, 26th.	
25			Depression extreme S. of British Isles.
26		Depression N.E. coasts or across Scotland; 26th; place undefined; uncertain.	Depression Bodo to Finland, 26th or 27th.
27	UNSETTLED PERIOD.	Depression S.W. coasts on S., 27th or 28th.	Depression Lake Onega, 26th, 27th. High pressure S. Scandinavia and Baltic.
28			Depression N. of France, 28th or 29th.
29			Depression little to N. of Christian-
30		Depression, Stornoway, 30th; probably deep to S. Scandinavia.	sund, 28th or 29th, No. 5. Depression near Sicily, 28th, 29th.
31			Anticyclone France and in S.W. of B. Isles, 30th and 31st.

The stormy periods when central area of depression passes near British Isles, are, from 4th to 7th; between Iceland and N. of Scotland; and 15th to 20th, N. of Scotland. Across N. of Scandinavia to Finland, 26th to 29th.

* Depression of 15th uncertain.

Date.		British Isles. JUNE.	Outside British Isles.
1			Stormy N.W. Atlantic, 1st to 5th.
2	ANTICYCLONIC PERIOD IN N. AND N.W. TO 3RD OR 4TH.	Depression S. coasts; 2nd or 3rd; probably S. England.	Depression between Faroe Isles and Shetland, 1st or 2nd, No. 1.
3			
4		Depressions N.W. coasts; 4th or 5th, uncertain.	Highest Anticyclonic pressure over N. Germany and Central Europe, 3rd, 4th.
5			
6		Depression W. of Ireland, 6th; uncertain.	Depressions N. of Spain, 5th to 8th. High pressure S.E. Europe and S. to Central Russia.
7	ANTICYCLO. IN W. AND OVER ENG.	Depression Shetland; 6th or 7th, uncertain.	
8			
9		Very squally 9th to 13th in N. and N.E.	Depression Bodo to Uleaborg, 8th to 9th. On 10th or 11th Christiansund, No. 2.
10	STORMY PERIOD IN N. AND N.E., AFTER IN S.	Depression Shetland, 10th, 11th; deep to Denmark.	Depressions Bay of Biscay to France, 10th or 11th.
11		Depression N. of Shetland, 11th or 12th, to S. of Sweden.	Depression Lake Ladoga, 9th or 10th; Spain, 10th.
12			Stormy weather between 12th and 14th over Baltic, N. Germany, Poland; probably also over Greece, Turkey.
			Stormy S. Europe, 10th, 11th, 12th.
13		*Depression S.W. coasts of Ireland, 12th, 13th, probably to France; squally in S.	Depression Faroe Isles, 12th, 13th, No. 3.
14			Depression Bodo, 14th or 15th, No. 4.
15		Depression 14th, S.W. coasts.	Depressions Bay of Biscay; probably to N. of France, Belgium and Baltic, 13th to 15th.
16	ANTICYCLONIC PERIOD.	Depression extreme N. coasts, 16th, uncertain.	
17		Anticyclonic Period; probably highest 16th, 17th.	Depression S. of France, 17th; uncertain.
18			Depression, probably S. of England to N. Sea, 18th or 19th; place undefined. If these depressions arrive the Anticyclonic pressure will be interrupted on 18th and 19th.
19		Depression S. of England or N.W. coasts, 18th or 19th, uncertain.	
20		If this depression arrives anticyclonic pressure will give way on 18th.	
21			
22			Depression to N. of Christiansund, 22nd.
23	STORMY PERIOD AFFECTING ALL ENGLAND.	Depression; probably across N. of England; 23rd, uncertain.	Stormy in Atlantic, 22nd to 24th.
24			Depression extreme N. of Scandinavia, 24th, 25th.
25		No. 1 Shetland; 25th, No. 2 W. of Scotland to N. Sea. No. 3 Stornoway or W. of Ireland, 26th.	
26			Depressions Spain, 25th to 26th.
27			On 26th and 27th the area of depression is shown to be, theoretically, over the S. of Scandinavia and N. Germany. Depressions near Swinemund, N. Sea, Gothland, or one large depression. Low, centre of Mediterranean.
28	ANTICYCLONIC PERIOD.	Depressions S. coasts of Ireland, 28th, 29th.	
29			
30		Depression approaching Ireland.	

The stormy periods when central area of depression passes near British Isles, are, from 9th to 12th or 15th. The storm track passes Faroe Isles to S. of Scandinavia or N. of Denmark between 10th and 13th. From the 6th to 15th probably very stormy and unsettled; and during the latter part of this period over W. Europe. British Isles, 23rd to 27th. Very stormy for the season between 23rd to 27th.

* This depression uncertain.